Technology and Employment in the Cotton Industry of Bangladesh

Mohammed Reazul Islam

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LIST OF ABBREVIATIONS AND ACRONYMS USED

AIFCOSPIN	All India Federation of Cooperative Spinning Mills Ltd.
ATDA	Appropriate Technology Development Association
ATIRA	Ahmedabad Textile Industries Research Association
BDT	Bangladesh Taka
BHB	Bangladesh Handloom Board
BIDS	Bangladesh Institute of Development Studies
BJSS	Bangladesh Jatiya Samabay Samity Ltd.
BMR	Balancing, Modernization and Replacement
BMTF	Bangladesh Machine Tools Factory
BSCIC	Bangladesh Small and Cottage Industries Corporation
BTMC	Bangladesh Textile Mills Corporation
DCF	Discounted Cash Flow
DLI	David Livingstone Institute of Overseas Development Studies
EPSIC	East Pakistan Small and Cottage Industries Corporation
IBRD	International Bank of Reconstruction and Development
IRR	Internal Rate of Return
ITIS	Intermediate Technology Industrial Service
KVIC	Khadi and Village Industries Commission
NIP	New Industrial Policy
NPS	National Pay Scale
NPV	Net Present Value
PVC	Present Value Cost
RFC	Rural Fabric Centre
SC	Service Centre
UNECLA	United Nations Secretariat of the Economic Commission for Latin America.

Chapter One

Introduction

This study examines the characteristics of cotton textile production in Bangladesh in some detail, identifies a range of alternatives from modern, intermediate and traditional technologies that are feasible under the operating conditions in Bangladesh and, at least implicitly, evaluates the present government policy of freezing the expansion of mechanized looms in the cotton sector.

An overview of the textile industry of Bangladesh is presented in chapter two. It is seen that the cotton textile industry is highly significant in its basic needs, employment and contribution to manufacturing value added. Textile policy during 1973-88 aimed at protecting employment in the handloom sector (Bangladesh, 1988a, pp. 5, 20). Moreover, the development plans advocated employment expansion in this sector through increases in productivity, setting up marketing channels and financial measures. The expansion of spinning capacity during 1973-81 was entirely organized within the public sector (Bangladesh Textile Mills Corporation [BTMC]), as this was the only sector producing yarn for the country. However, in policy changes since 1982, private-sector participation was encouraged, and all Bangladeshi-owned textile mills, which had been nationalized following independence in 1972, were returned to their previous owners. This policy change, however, maintained the strategy of non-expansion of mechanized looms in the cotton sector.

Development plans during 1973-90 emphasized expansion of spinning capacity to 1.83 million spindles. However, the actual growth in capacity fell far short of the plan target. It reached about 1.27 million in 1988. Per-capita cloth consumption reached only about 7.9 m^2 against the third five-year-plan target of 11 m^2.

The textile industry suffers from three major problems. First, spinning and weaving machinery ranges in vintage from the early 1920s to the mid-1980s. Also, heterogeneity of machinery sources resulted in lack of availability of spares and maintenance, causing inefficiency in the industry (Ahmed and Rahman, 1979, p. 214). The industry needed an urgent modernization of a substantial capacity. Although some modernization took place, the pace and the extent of it did not meet the requirement. Second, the utilization of capacity by the mills both for spinning and weaving, is very low. During the postindependence period (1972-88), the utilization level of the years before independence was not achieved for spinning. Capacity utilization has been low due to age of the machinery, power failure and absenteeism. During 1980-88, between 4% and 14% of total production hours were lost because of power failure. In 1988, spindle and loom productivities achieved were about 21.4% and 20.9% lower than the pre-independence level (1970). Third, the enterprises suffer from inefficient management and an ill-motivated workforce, resulting in continuous losses in the enterprises.

The textile industry, however, has a great potential for expansion. Taking the third 5-year-plan target of per capita cloth consumption of about 11 m^2 as a measure for the required expansion, it is estimated that there has to be something like a doubling in spinning and a four-fold increase in the present loom capacity (1 500 000 spindles and 28 000 looms) if the consumption target is to be met by expansion in the modern sector. Alternatively, if the target is to be met by modern spinning and handloom weaving then there is need for an expansion of about 60 modern spinning units, each with 25 000 spindles, and 200 000 additional handlooms.

For a industry with such an expansion possibility, economic efficiency and provision of employment are of paramount importance. The choice of correct production techniques is the prerequisite for meeting the planning objectives.

The policy on technology choice in different development plans (1973-90) has emphasized that, in view of the scarcity of capital and the comparative abundance of labour, the primary objective should be to adopt labour-intensive technology. The technology should also, however, be economically efficient. However, the policy followed has not differentiated between the efficiencies of capital- and labour-intensive technologies. It seemed to imply that although both sets of technologies generate surplus, labour-intensive technology should be adopted as long as it generates some surplus. Such policy clearly countenances losses in efficiency and therefore adversely affects economic development. However, the policy emphasized the improvement in efficiency of labour-intensive technology (Bangladesh, 1985, p. 107; 1988a, p. 30).

An examination of techniques in large- and small-scale production shows that economically efficient alternatives are available, and technology choice in textile production does not suffer from any technological rigidity (UNECLA, 1966, pp. 4-5; Pack, 1976, pp. 155-156; Pickett and Robson, 1977a, pp.205-206, 1979, pp. 28-30, 1981, pp. 66-70; Boon, 1979, pp. 69- 73)). Such alternatives could be within modern technologies from different sources and subprocesses, inheriting various labour and capital complements, and from technologies suitable for small-scale and cottage production.

The study requires a technique for identifying the alternative technologies that are technically feasible under Bangladesh conditions. One such methodology, developed by the David Livingstone Institute, has been used here (DLI, 1975, pp. 27-50). The methodology also identifies the data requirement for the appraisal of the alternatives. Finally, the methodology includes the costing of the technologies, incorporating both investment and operating costs; the discounted cash flow (DCF) method has been used for the evaluation (chapter three).

A detailed examination of the alternatives shows that many technically feasible technologies could be operated in Bangladesh. Of these, 12 alternatives, which are widely practiced in India, have been chosen for final economic evaluation. These technologies range from alternatives within the modern sector (four) to combined technologies, i.e. combination of modern, intermediate and traditional technologies (eight). The modern alternatives comprise turnkey techniques by considering a single set of equipment from four sources -- the U.K., Japan, India and Romania. The source of intermediate technologies has mainly been India. Such technologies use power spinning and pedal looms, developed by the Appropriate Technology Development Association (ATDA), Rural Fabric Centre (RFC) and the Khadi and Village Industries Commission (KVIC), India. Hand spinning (ambar charka), which is another alternative, was also developed in India by KVIC. However, traditional technologies (i.e. handloom weaving) are represented by the indigenous option. These 12 alternatives have been evaluated using techno-economic parameters such as productivity level, wage rate etc., established from an intensive survey of Bangladeshi and Indian textile industries (chapter four).

The evaluation of alternatives shows that an output of 31 million m^2 of cloth provides maximum technical economy of scale, and this is the base on which the alternatives are compared. The product chosen is grey cloth of 2126 picks and 2126 ends per square metre, using yarn of 32s cotton count for ends and picks. This product represents more than 80% of the country's total cloth production. The selection of machinery, manning levels and space requirements of alternatives is based on this output level. To meet this scale of output from a modern spinning or a composite unit, an equivalent of 20 intermediate spinning and composite units and 240 KVIC units and between 10 640 and 13 820 handlooms would be required depending on their types. The employment potential and skill composition vary considerably. For example, modern composite technology provides the lowest employment of 1599, while its skill requirement is higher. On the other hand, in hand-spinning combined with handloom, the employment generation is the highest at 56 884 but the skill component is significantly lower (chapter five).

The costing of the alternatives incorporates investment and operating costs. The investment cost of the technologies combining modern, intermediate and traditional technologies is relatively lower than that of the alternatives in the modern sector (Indian, Romanian, Japanese and U.K. technologies). Their investment cost is between 3% and 30% less than each of the modern alternatives. On the other hand, the operating cost of the combined alternatives is between 30% and 220% higher than that of the modern (chapter six).

Main findings of the study

The main findings of the study can be summarized as a comparison of: (a) different sources of modern and intermediate spinning alternatives supplying yarn to the handloom sector; (b) alternatives among the traditional technologies, i.e. pit- and CR (semi-automatic)- handlooms; and (c) the composite technologies (spinning and weaving) from different sources of modern and combined (modern, intermediate and traditional) alternatives (chapter seven).

Among spinning technologies, all modern spinning from India, Romania, Japan and U.K. are found more efficient than the intermediate spinning alternatives developed in India. The ranking of the spinning technologies shows that the modern Indian spinning (least-cost) has the lowest present-value cost (PVC) followed by the Romanian (second best), Japanese and U.K. technologies. Among the intermediate spinning, RFC power spinning is the best option followed by ATDA Pedal and KVIC hand spinning. All spinning alternatives generate net loss in NPVs, i.e they have negative surplus. It therefore emerges that the per-unit selling price is lower than the cost of production irrespective of the production technology. This indicates that the low selling price of yarn could be an indirect policy of the government to sustain handloom production by subsidizing the handloom weavers. An increase in productivity to the manufacturers' recommended (expected) level, assuming management inefficiencies are minimized, does not increase the economic efficiency significantly; the technology ranking remains the same. This, however, increases the acceptability of the least-cost, second-best and RFC power spinning relatively more over the other alternatives. All spinning technologies still have negative surplus, but the magnitude of the loss in NPVs decreases.

The cost of creating additional employment to that provided by the least-cost is not attractive among the modern spinning alternatives; however, it is worth considering for the combined alternatives, provided economic sacrifices are made. The second-best technology provides 3.8% more employment than the least-cost; the cost per job of additional employment is BDT 74 740 if the second-best option is chosen. Japanese and U.K. spinning have higher PVCs than the least-cost and second-best technologies but provide 2.2% and 3.6% less employment and are, therefore, rejected as acceptable options. Among the intermediate alternatives, KVIC spinning provides the highest employment (35 040) at an additional cost of BDT 17 030 per job. The cost of an additional job for ATDA pedal spinning is marginally higher at BDT 17 330, and for RFC power spinning the cost is BDT 26 290. However, RFC power has the lowest PVC in excess of minimum over the least-cost technology. This makes RFC power spinning the most attractive option with employment expansion possibility 5.39 times more than the least-cost technology.

Among the traditional technologies, three important alternatives have emerged. First, alternatives between pit- and CR-looms; second, the alternatives based on the sources of yarn supply either from modern or from intermediate spinning and, finally, when traditional preparatory weaving is replaced by the Service Centre (SC) and processed warp beam is supplied to the handloom sector. It has emerged that irrespective of the sources of supply, the pit-loom is relatively the more efficient option. In terms of efficiency ranking, the pit-loom, when supplied with processed beam from the service centre, emerges as the least-cost option, having the lowest PVC and 25% more employment potential over the CR-loom, followed by supply sources from intermediate RFC power spinning and modern least-cost spinning.

The pit-loom has a positive NPV when the processed warp beam is supplied by the service centre and the yarn is supplied from RFC power spinning. However, it incurs a loss if the source of yarn is modern spinning. The relative advantage of intermediate spinning emerges from the saving on marketing and distribution cost. It is worth noting that intermediate production units are assumed to be located in handloom-concentrated areas, having 5% marketing and distribution cost as compared to 10% on ex-factory price of yarn for modern spinning. Handloom weavers face higher yarn cost because of credit purchase; the interest payments on such purchases could vary from 30% to 200% (Miyan, 1979, pp. 116-117; Bangladesh, 1982 a, pp. 61-62; van Leeuwen and de Ruiter, 1982, p.61; Islam, 1989, pp. 55-60), which makes handloom weaving increasingly inefficient. Therefore, a developed marketing and distribution system will contribute toward the economic wellbeing of this sector (Bangladesh, 1982a, pp. 37-47; 1988a, p. 28).

Among the twelve composite (spinning and weaving) alternatives from different sources of modern and combined (modern, intermediate and traditional) technologies, the modern alternatives, irrespective of their sources, are relatively more efficient than the combined technologies. Among modern sources, the Indian technology emerges as the least-cost, with lowest PVC, followed by Romanian as the second-best. Among the combined alternatives, the option combining least-cost spinning, service centre and pit-loom emerged as the best, closely followed by RFC composite unit with power-loom, the least-cost spinning and pit loom and the least-cost spinning and CR-loom. The remaining alternatives combining RFC spinning and pit-loom, ATDA spinning and pit-loom, RFC composite pedal-loom and KVIC spinning and pit-loom, have substantially higher PVC, complemented by higher employment. All modern alternatives generate surplus or have positive NPVs. However, among the combined alternatives, only the least-cost spinning, service centre and pit-loom generate surplus, while all the remaining alternatives have negative NPVs. The most labour-intensive technology (KVIC spinning and pit-loom) has the highest negative NPV. Least-cost spinning, service centre and pit-loom is the only economically efficient option that does not require any subsidy, and it provides 11 times more employment than the least-cost technology. This again confirms the suitability of the service centre as a replacement for traditional preparatory weaving processes.

The cost of creating additional employment over the least-cost is not found attractive, as in spinning, among the modern composite alternatives. Such a possibility is however worth considering among combined alternatives. The second-best option provides additional employment of 2.2% over the least-cost alternative; the creation of an additional unit of employment incurs a cost of BDT 306 840. The Japanese and U.K. technologies have higher PVC than the least-cost but provide 0.77% and 5.77% less employment respectively. They are, therefore, rejected on the grounds of inefficiency. Among the combined technologies, alternatives combining least-cost spinning, service centre and pit-loom (employment: 18 886) and least-cost spinning and pit-loom with traditional preparatory weaving (employment: 22 852) are the most efficient in terms of employment expansion. The cost per additional job for these technologies is BDT 8260 and BDT 9580 respectively. This clearly shows that considerable improvement in efficiency can be made if the traditional preparatory process of weaving is replaced by service centre. The option with highest employment potential, KVIC spinning and pit-loom (employment: 56 884), generates 33.5 times more employment than the least-cost, but its cost per additional job is between 42% and 65% higher than the above two combined options. It is therefore, again, not an efficient option.

Improvement in productivity has importance in selecting technology options and increasing economic efficiency (Pickett and Robson, 1977b, pp. 879-882). Increase in productivity level has increased efficiencies of all alternatives, though not significantly, and the ranking of alternatives remains unchanged. Among modern alternatives, the efficiency of the least-cost and the second-best options increases more than the other options. Among the combined alternatives, least-cost spinning, service centre and pit-loom increase efficiency, and thereby surplus. RFC composite technology with power-loom becomes surplus generating, and the options favoured by the textile policy still have negative NPV and, therefore, require a surplus. Less efficiency gain despite an increase in productivity is mainly due to two reasons. First, raw material constitutes about 60% of the total operating cost. Second, the actual level of productivity assumed for this study may be over-estimated because of the difficulty in estimating production loss due to power failure, mechanical breakdown, absenteeism etc. Nevertheless, these variations in productivity levels do not affect the conclusions arrived at in this study.

Efficiency price evaluation

Using corrected factor prices for two major inputs, capital and labour, the economic efficiency of selected alternatives has been examined. The adjustment of factor costs has been only for the imported component of investment, while for labour, adjustments were made only for semiskilled and unskilled workers (NEI, 1980, pp. A. 4-6,14-15).

The ranking of the least-cost (Indian) and the second-best technologies remains unchanged when using these adjustments in factor costs. However, among the combined alternatives, the RFC composite technology with power-loom emerges as the technology having the lowest PVC, followed by the option combining least-cost spinning, service centre and pit-loom. This shows that the RFC composite option using power-loom benefits most from efficiency pricing and emerges as a more efficient option than the technology in which service centre replaces the traditional preparatory weaving. In terms of surplus, NPVs of the least-cost and second-best alternatives decrease by 9% and 10% respectively. On the other hand, the RFC composite option increases its surplus significantly. The modern least-cost spinning, service centre and pit-loom option still generates a net surplus and therefore remains an attractive alternative with a two-fold employment expansion possibility compared to the RFC composite technology.

It emerges, therefore, that there are a number of alternatives in textile production among which the modern options are unequivocally efficient, but have low levels of employment. Combined alternatives, in general, require subsidies, except one option (least-cost spinning, service centre and pit-loom). This option has the potential to increase employment 11 times, but it sacrifices surplus. The technology options that the textile policy favours and are at present used widely in practice are least-cost spinning and pit-loom and least-cost spinning and CR- loom. Additional cost per job to keep these technologies operating on the ground of sustaining employment in the handloom sector are BDT 12 710 and BDT 11 380 compared the least-cost option. This shows that even with the technologies in practice in Bangladesh, a substantial gain in efficiency can be attained by replacing the traditional preparatory weaving by service centre to supply processed warp beam to the handloom weavers. During the transition of the handloom industry in India, due to competition from the power-loom sector, the loss of employment occurred mostly in preparatory weaving, where half the jobs were lost between 1974 and 1981 (Jain, 1983, pp. 1517-1526). From what has been said, it is clear that the present textile policy -- of using modern spinning methods and providing employment through protection of handloom weaving by prohibiting any increase in modern weaving -- is economically not justified.

Finally, although the study has brought information on the economy and the textile industry up to date to 1988, the input-output parameters used for evaluation of alternatives were not revised and remain at the level of 1981. It is found that a revised evaluation would not be worth undertaking. During 1981-88, from the investment side, the cost of construction increased by about 95%, while machinery cost increased by about 78%. Total investment cost has increased on an average for all alternatives by about 80%. On the other hand, considering operating costs, the price of raw cotton has increased by 68%, electricity cost by 253% and labour and salary cost by about 100%. On an average, there has been an increase of about 105% in operating costs for all alternatives. This will clearly increase relative PVCs of alternatives in 1988 compared to 1981. As the productivity levels of modern, intermediate and traditional technologies hardly changed, modern alternatives will continue to show higher efficiency than the combined alternatives, and the ranking established previously will remain. In output prices, the average price of yarn and cloth has increased by about 87%. This increase is less than the increase in cost of production and is not sufficient to offset the technology ranking and, therefore, most of the combined alternatives will continue to require subsidy.

Chapter Two

Bangladesh: its economy and textile industry

Bangladesh covers 144 000 km^2 and in 1988 it had a population of 106.6 million, which was growing at an annual rate of 2.4%. Thus it is one of the most densely populated countries in the world with 740 persons per km^2. The adult literacy rate is about 29%, which is much lower than in many countries in Asia. The gross domestic product (GDP) in 1987-88 was BDT 85.55 billion at 1972-73 prices, generating a per-capita income of BDT 802 (Bangladesh, 1988b, p 486). The economy is dominated by agriculture, which contributes about 48.4% of GDP and provides a livelihood to about 74% of the population. The industrial sector is growing but remains relatively small; in 1988 it contributed only 9.8% to GDP and only 11% to total employment.

At the time of partition of India in 1947, East Pakistan (now Bangladesh) had little industrial development. Only 4% of GDP was generated in this sector, most of it in small and cottage industries. During the 1950s and 1960s, East Pakistan passed through a period of planned economic development. Real annual growth of GDP in the 1950s was around 2% (Hossain and Walliullah, 1975, pp. 2-10) However, most of this growth was eroded by population increase.

The annual growth rate during Pakistan's second 5-year plan (1960-65) was 4.4% (Pakistan, 1968, pp. 352-354). During the subsequent 5-year plan (1965-70), the growth rate was sustained at around 4%. However, the population grew at the rate of 3% a year in the 1960s; per-capita income, therefore, increased for all Pakistan by only about 1% a year during the third plan of 1965-70 (Pakistan, 1970, p. 535).

Table 1 shows annual GDP growth rates of -14% to 9.6% during 1970-88. The decline in growth in the first 2 years of this period is the result of disruption during the independence war.

The balance of trade of Bangladesh is characterized by a massive deficit. Table 1 shows that the trade deficit increased steadily from BDT 4.35 billion to BDT 55.39 billion during 1974-88. Exports in 1988 earned only about 41% of the total import bill.

One of the principal exports of Bangladesh in 1987-88 was ready-made garments (35.24% of the total value of exports). Other exports were raw and processed jute (31.1%), leather hides and skins (11.95%), fish and fish products (11.34%), tea (3.16%) and furnace oil, paper, newsprint, handicrafts and miscellaneous items (7.21%) (Bangladesh, 1989a, pp. 213-226). Thus the foreign-exchange earnings of the country depend largely on garment export.

On the other hand, the manufactured goods classification of materials, machinery and equipment constitutes 28.66% of the total value of imports. Food and other consumables -- sugar, edible oil and oil seeds -- constitute about 24.38%, oil, lubricant, petroleum products, fertilizers and cement constitute about 12.83%, raw cotton, yarn and fabrics about 8.53% and chemicals and medicines about 5.79%. Miscellaneous manufactured goods contribute 19.81% to total imports.

There has been a steady flow of investment over the last 16 years. Table 1 shows that public and private investment increased respectively from BDT 2.58 billion to BDT 44.80 billion and BDT 1.45 billion to BDT 31.09 billion during 1972-73 to 1987-88. However, domestic savings have been able to finance only a small fraction of the total investment. The rate of domestic savings has risen from 0.1% of GDP in 1972-73 to 3.63% in

1987-88, attaining a maximum of 3.66% in 1986-87. The low rate of savings is due to the extreme poverty of Bangladesh, her disaster-prone economy and severe inflation (Bangladesh, 1980a, pp. I.9-10).

Total investment is financed largely through external assistance. It was only in 1976-77 that domestic savings financed more than one-third of the total investment cost.

According to a World Bank document (IBRD, 1982, pp. 52-59), the productivity of the labour force of Bangladesh is severely limited by the shortcomings of the educational system. Annual growth rates during 1973-88 for enrollment at primary, secondary and tertiary education institutes range from 2.2% to 3.4%.

During 1947-73, the dominant strategy was to expand the education system rapidly. The expansion, however, barely kept pace with the growth of population, so that only a small proportion of the people learned basic reading, writing and arithmetic; the educational system has done little to alleviate the acute shortage of skilled workers and mid-level technicians. Thus education has, since independence, failed to meet the requirements of the different sectors of the economy. Moreover, the emigration of skilled workers and technical and professional personnel to the Middle East and elsewhere increased after independence.

The industrial policy of the 1950s sought to encourage private industrial entrepreneurs. An overvalued Pakistan currency promoted investment in capital-intensive industry, while the public sector grew at a lower rate than anticipated. After Bangladesh achieved independence from Pakistan in 1971, development proceeded by way of a first 5-year plan, 1973-78, a 2-year plan, 1978-80, a second 5-year plan, 1980-85 and a third 5-year plan, 1985-90. The first 5-year plan aimed at the ascendancy of the public sector, the private sector being confined to small-scale cottage and informal sectors (Bangladesh, 1973, p. 213). The strategy of the plan was to meet mass-consumption needs through labour-intensive investment and unconventional measures to mobilize labour (Bangladesh, 1973, p. 6). The government, in its nationalization policy of March 26, 1972, paved the way for the state to take over jute, textiles, sugar, chemical and other large manufacturing industries.

The private sector was left to operate in small and cottage industries. The entrepreneur was allowed to invest to a maximum of BDT 2.5 million. This investment ceiling was not sufficient to undertake any efficient manufacturing activity. In July 1974, to encourage private-sector investment in small- to medium-scale industries and also to meet the sharp increase in investment costs, the government raised the investment ceiling to BDT 30 million. This ceiling was further raised to BDT 100 million in 1975, and it was finally abolished in September, 1978. Private participation was extended in many large manufacturing industries, including jute, textiles and chemicals, along with a liberal foreign exchange allocation policy to facilitate buying machinery and equipment from abroad (Bangladesh, 1980a, pp. IX 3-5). The most significant industrial policy reform favouring the private sector took place in June, 1982. This new industrial policy (NIP) allowed the transfer of state-owned jute and cotton textile mills to local owners. Moreover, restrictions on private investment were liberalized (Bangladesh, 1982c, pp. 1-12). The third 5-year plan incorporates the industrial policy of 1986. This policy further encourages private-sector participation in industrialization and allows divestment of 49% of share in some public enterprises to private investors. The plan anticipates increased private investment in the total 5-year investment plan from the 35.5% of the second 5-year plan (1980-85) to 55%. Private-sector participation is extended to all sectors of the economy, except armaments, nuclear energy, telecommunications, air transport, electricity generation and distribution and mechanized forestry.

The first 5-year plan emphasized new employment through the expansion of small and cottage industries, which now contribute about 40% of the total value-added and employs 75% of the labour force in the industrial sector. These industries require less capital per unit of employment and output, which makes them attractive in the light of the resource constraints of the country. The subsequent 2-year plan re-emphasized small and cottage industries and urged diversification of the industrial base for domestic and export markets through use of indigenous materials and skills (Bangladesh, 1978a, p. 163). It recognized the inability of agriculture to absorb the growing labour force and stressed the role of labour-intensive small and cottage industries in expanding employment.

Rural (i.e. cottage) industries could, with less infrastructure, provide goods for the local market. This could help to distribute income equitably and lead to balanced economic growth. However, these objectives were not achieved by 1985. The third 5-year plan states that the growth of agriculture could create short-run employment, but in the long run, even with full development of crop production, it cannot absorb all in the labour market. There will remain surplus labour for whom employment needs to be created. Sufficient employment cannot be provided through promotion of rural industries alone, but the plan suggests substantial employment can come from non-crop sectors like fisheries and livestock. However, rural non-farm activities are a low-income sector because of low investment and demand. A comprehensive rural development program is essential; it should enable agriculture and industry to reinforce each other by increased supply and demand of goods, thereby increasing employment. Other than the above, the first 5-year plan and 2-year plan contained no well-defined policy on selection of production technology. For industries where there is no alternative to the adoption of modern technologies, emphasis should be on those that generate more employment (Bangladesh, 1973, p.16; 1978a, p.33). The second 5-year plan addressed the past investment incentive system. This had favoured large-scale, capital-intensive projects, for which foreign exchange had been available at an artificially low rate, whereas small producers had to pay market prices for equipment. The second 5-year plan set out measures for adoption and development of appropriate technology, notably correcting price distortion, selecting public sector projects on the basis of their social costs and benefits, adopting efficient labour-intensive alternatives and setting up a national technology centre. More explicitly, the plan outlined the following policy guidelines:

- In view of scarcity of capital and comparatively abundant supply of labour, emphasis should be on the adoption of labour-intensive technology.

- Priority should be given to development of medium, small and cottage industries that have high ratios of labour use per unit of capital and low ratios of capital per unit of output.

- Even where modern technology has to be chosen, plants that are less capital-intensive with greater flexibility to use maximum manpower and ancillary operation should be chosen.

- Improvement of economic efficiency and labour-productivity will have to be given adequate importance.

The third 5-year plan emphasized that the inappropriate choice of technology is mainly the result of the lack of a well-defined science and technology policy relating to national economic development (Bangladesh, 1985b, pp. 108-112). It emphasized that inappropriate pricing of capital (such as through low interest rates) and low tariffs favour capital-intensive technologies against labour-intensive ones.

It emerges, therefore, that all four plans during 1973-90 emphasized the role of small and cottage industries in the creation and expansion of employment. Modern technologies have been advocated only in the import-substitution industries; even in such cases the labour-intensive option should be preferred.

The cotton textile industry

In 1987-88, textiles contributed about 11% of the total value-added in manufacturing. The industry manufactures mainly yarn and fabric from cotton, rayon, silk and other fibres. Of these, cotton is the most important; it contributes about 75% of the total textile value-added, and rayon, silk and other fibres contribute the remaining 25%. The present study is concerned only with cotton.

The history of cotton textiles in Bangladesh is interwoven with that of cotton manufacture in the Indian subcontinent. Archaeological evidence suggests that cotton fabric was in use in the subcontinent as early as 3000 B.C. (Rath, 1981, p.1). In the 16th and 17th centuries, cotton manufacturing was well developed in the subcontinent, and trade links had opened with the West. Muslin from Dhaka and calico and corah from other parts of the subcontinent were leading exports in the days of the East India Company (Rath, 1981, p.3). The turning point of the textile industry was the Industrial Revolution in England. Important innovations took place in the conversion of cotton fibres to yarn and cloth. Among these were the flying shuttle by John Kay (1733), the spinning frame by Richard Cartwright (1785) and the saw gin by Eli Whitney (1793).

Technological development reduced the cost of processing considerably and led, in the early 1800s, to the growth of Manchester as the most important centre in the world for manufacture and trade in textiles. In the wake of machine spinning, hand spinning faced technological obsolescence, and by the early 19th century, the subcontinent ceased to be an exporter of cotton cloth and emerged as an exporter of raw cotton. In the late 1800s, hand spinning was almost discontinued because of fierce competition from mill-made yarn, but the traditional handloom did survive in the subcontinent.

The first cotton textile mill to be set up in the subcontinent was in West Bengal (now part of India) in 1811. Later growth of textile industries took place in Bombay and Ahmedabad. The growth of Bombay as an important textile centre was the result of its port and railway facilities, whereas Ahmedabad, which is in a cotton growing area, has a climate suitable for cotton spinning (Rath, 1981, pp. 7-11). In 1945, undivided India had 417 mills with 10.3 million spindles and 192 000 looms.

It was not until 1908 that the first mill was set up in East Bengal (now Bangladesh) with only eight looms (Muslim, 1969, p. 2). East Bengal was not a growing area and was supplied with raw cotton from other parts of India. Narayanganj, one of the finest river ports in the country, developed as an important centre for cotton trade. Most of the cotton-textile manufacturing in Bangladesh developed in and around the Narayanganj area due to (a) adequate infrastructure, especially power, transport and finance; (b) important markets for inputs and outputs; (c) the largest concentration of handloom; and (d) its trade links with Calcutta. During 1908-47, 11 textile mills were established in East Bengal, some with very small capacity, and Narayanganj accounted for more that 75% of the spindle capacity (Chowdhury, 1977, pp. 397-403).

At partition, most cotton manufacturing was in what became India, whereas much of the cotton-growing area of the Indus basin became part of West Pakistan. This was said to have caused a 40% shortfall of raw material in the Indian textile industry (Rath, 1981, p. 22). In 1947, Pakistan inherited 21 textile mills, 11 in East Pakistan and 10 in the West, comprising 177 000 spindles and 4800 looms. This manufacturing capacity formed only 1.7% and 2.5% of the subcontinent's spindle and loom capacities respectively.

The policy of Pakistan after independence in 1947 envisaged private-sector participation in the import substitution industries (Pakistan, 1957, pp. 85-86). The cotton textile industry had all the conditions for development as an import- substitution industry. The country had a large supply of raw cotton and a domestic market for cotton products. Indeed Lewis (1970, p. 2) has suggested that given these factors, the rapid growth of cotton manufacturing would inevitably have occurred, even without official support. In the 7 years of the pre-plan period (1947-54), the country turned from almost complete dependence upon imported yarn and cloth to a point close to self-sufficiency (Pakistan, 1957, pp. 442-444). However, this growth was unequally distributed between the two wings of Pakistan, as Table 2 indicates.

From 1947 to 1970, the absolute number of spindles and looms in East and West Pakistan increased by 651 000 spindles and 4420 looms and 2 522 000 spindles and 27 780 looms respectively. However, the number of spindles and looms in East Pakistan between 1968-69 and 1970-71 remained almost stagnant due to political unrest.

The concentration of textile capacity in West Pakistan can be attributed to various factors. These include the dominance of Karachi in trade and commerce. At the time of partition, immigrating Muslims with considerable skill in cotton trading settled around Karachi and located their enterprises there (Chowdhury, 1985, pp. 49-65). These entrepreneurs and managers had easy access to the central government, which was at that time located in Karachi. During 1955-71, an array of government policies had the effect of favouring West Pakistan and led to the transfer of the foreign exchange earnings of East Pakistan to the western province. These policies included an overvalued Pakistan currency, protection from imports, an export levy and a system of licensing private industry for commercial and industrial imports -- during 1957-64 East Pakistan received less than one-third of total Pakistani imports (Papanak, 1967, pp. 19-24; Lewis, 1970, pp. 153-56). In addition, the West benefited from a high share of the cheap loans allocated for private investment by the Industrial Credit Banks (Ahmed, Q.H. 1981, pp. 7-8). All these combined to make possible the rapid growth of the cotton textile industry during 1947-71 in Pakistan. However, the fruits of this growth were unequally distributed.

The cotton textile industry in Bangladesh can be divided into two main groups --the modern (organized) and the traditional (dispersed) groups. Mill production of yarn and cloth in large-scale industry mainly uses imported machinery and is part of the organized modern group. The traditional group comprises mostly cottage manufacturing based on hand-spinning and handloom weaving.

The organized segment may further be divided into public and private enterprises. The public sector, which includes spinning, composite and integrated mills, spun all the yarn during 1971-82. The private sector, during that period, was confined to weaving; most private mills used nylon and polyester fibres. In 1988, 72 weaving factories with 1780 looms were privately owned in Bangladesh. Of these, only six large factories manufactured cotton goods, mostly sheets, towels and umbrella cloths, and the others manufactured synthetic fabrics. Since 1982, government policy has allowed the private sector to spin and weave cotton. A total of 27 textile mills having 522 000 spindles and 4500 looms were denationalized.

The hand spinning practiced in the dispersed sector is not significant. About 5000 hand-spinners are located mainly around Comilla. They use bamboo or wooden devices called "charkas" to produce about 90 000 kg of 10-20-count yarn for use in handlooms (Bangladesh, 1981b, p. 10). A philanthropic organization (the only one of its kind in the country) organizes integrated cottage production from hand spinning to weaving, dyeing and finishing. It has organized 800 hand-spinners, some of whom work in the organization's workshop, but most of whom work at home, using raw materials supplied by the organization. The product of handspun yarn is mostly coarse fabric known as "khadi" or "khadder" and "khadi chadar" or "chadar". Most hand spinning is under some kind of cooperative management. The important part of the cottage industry is handloom weaving, which has a capacity of 437 010 looms, of which about 260 000 are operational (Miyan, 1979, pp. 42-43). In 1987-88, handlooms produced 665 million m^2 of cloth; this was 91% of domestic production of 731 million m^2 and 63% of domestic consumption of 1054 million m^2. The composite mills in the public and private sectors produced 66 million m^2 (9% of production and 6.3% of consumption). The Bangladesh Department of Textiles estimated private-sector power-loom and hosiery production at 31 million m^2 (4.2% of production and 2.9% of consumption). Thus total domestic production supplied 72.3% of consumption, the balance coming from imported new fabric (221 million m^2 or 21% of consumption) and second-hand cloth (102 million m^2 or 9.7% of consumption).

Table 3 shows how the value added of the various parts of the Bangladesh cotton industry have grown from 1972-73 to 1987-88 in comparison to each other and to all manufacturing. The decline of the relative importance of the cotton industry during this period (from 21.4% to 11.3% of all manufacturing) will be noted. Such estimates as are available suggest handlooms contribute only 10% of textile value-added. Growth in employment during the 16 years averaged 6.9% in manufacturing and 1.2% in the cotton mills. In 1987-88, the cotton mills were employing about 13.5% of the manufacturing labour force.

The value-added per employee of mill production is noticeably lower (63%) than that of total manufacturing industry. The value-added per unit of employee of the manufacturing industry increased from BDT 16 970 to BDT 82 460 during 1972-88, while for cotton-mill production, it increased from BDT 8500 to BDT 52 030. This represents compound annual rates of increase of 11.11% and 12.84% for total manufacturing and textiles respectively suggesting the higher degree of labour intensity of cotton textile production in Bangladesh.

Public- and private-sector modern-mill production and handloom weaving form the two important components of the cotton textile industry in Bangladesh.

When Bangladesh came into being, it inherited 44 textile units with a capacity of 750 000 spindles and 7000 looms under private ownership; in July 1972 all the large mills producing cotton textile were nationalized. The mills, brought under a state corporation, had more than 90% of the total capital employed in cotton textile production (BTMC, 1974, p. VI); they comprised spinning, composite (spinning and weaving) and integrated (spinning, weaving and finishing) units. The total textile capacity at the formation of the Bangladesh Textile Mills Corporation (BTMC) in June, 1972 was 835 000 spindles and 6800 looms. The increase in spindles and looms during 1972-88 included new and some modernized machinery.

During 1972-88, spindle capacity in the mills increased from about 835 090 to 1 273 520. This increased capacity can be ascribed to two expansion plans. Six new textile mills with 12 500 spindles were planned before 1971. The other expansion plan included 13 new textile mills each with about 25 000 spindles by BTMC and some new spindle capacity in the private sector. Recorded capacity grew by 2.85% on average per annum during 1972-88, attaining a maximum growth of 8.9% in 1985-86.

Loom capacity did not increase during 1972-88; in fact, it declined from 6800 to 6300. There has been no capacity increase in the private sector and BTMC did not have any new expansion of loom capacity until 1984. During this period, BTMC installed 1112 new looms. (Of these, 634 were installed in four textile mills already operating as spinning units, these looms were purchased before 1971; and 478 new looms were installed in two mills.) Of the total capacity, 614 looms were written off as obsolete. During 1972-88, the total number of looms fluctuated from a decline of 16.91% in 1983-84 to a growth of 8.46% in 1973-74.

The spindle-loom ratio in the mills increased from 116:1 in 1972-73 to 202:1 in 1987-88. This suggests imbalanced growth between spinning and weaving capacity favouring an increase in handloom activities in accordance with the policy of the government to encourage the handloom sector (Ahmed, Q.K. 1969, pp. 115-116).

In the first 5-year plan (1973-78) the emphasis on expansion was to increase spinning capacity by 400 000 spindles and weaving capacity by 4000 looms (Bangladesh, 1973, pp. 229-230). However, in the revised plan, expansion of weaving capacity was not felt necessary and attention was focused on the installation of 13 textile mills with 25 000 spindles and 4 with 12 500 spindles each. At the end of the plan period, spindle capacity had increased by 146 000 -- 39% of the target. The 2-year plan of 1978-80 had not proposed any new expansion of spindles and looms. However, it aimed to complete the ongoing projects; by the end of the plan, 84 240 more new spindles were installed.

The second 5-year plan of 1980-85 aimed to achieve self-sufficiency in cotton textiles, making available 10.97 m^2 of cloth per capita by the terminal year. The plan proposed to increase spindle capacity by 630 000; actual increase was 114 260, about 18% of the target.

The third 5-year plan (1985-90) does not propose any expansion of textile capacity through the public sector. Expansion programs are to be limited to balancing, modernization and replacement (BMR) and completion of ongoing projects. However, the plan proposes that the private sector take part in expanding textile spinning and specialized loom capacities.

As the development of the textile industry was directed at increasing the spinning capacity, finishing capacity hardly expanded during 1972-82. Of 24 BTMC weaving mills, 5 were composite and 19 integrated. All the latter have finishing capacities. Eighteen of them have dyeing facilities and four have printing facilities as well. The finishing capacity suffered from imbalance and underuse. The bleaching capacity considerably exceeded that for dyeing and finishing (NEI, 1980, pp. 23-24). A UNIDO study on BTMC mentions this finishing imbalance (Hassan, 1979, appendices III, IV). The average use of yarn dyeing and fabric finishing were 67% and 47% respectively. Underuse was attributed by the study to a shortage of raw materials, obsolete machinery and lack of spares and maintenance. The NEI report (1980, p. 23) estimated that 11 private finishing mills can dye 20.3 million m^2 and print 33.5 million m^2 of cloth annually. About 68% of BTMC fabric marketed in 1988 was in grey form, a substantial part of which was processed in the finishing mills of the private sector. During 1980-88, the private-sector dyeing and finishing capacity grew by about 29.% and 38.% respectively in order to process an increased quantity of polyester fabric from newly-set-up weaving mills. Demand for dyed or finished fabrics has increased since the 1970s; during 1958-71, almost four-fifth of the total production marketed was grey form (Chowdhury, 1981, pp. 411-412).

The only cotton processing machine successfully made in Bangladesh is the Reeling, which transfers yarn from ring-spinning bobbins to hank form. Private manufacturers and the state-owned Bangladesh Machine Tools Factory (BMTF) have been producing it since 1977. In recent years, private manufacturers have been producing semi-automatic looms, and BMTF produced a few frames of ring-spinning machinery, but these machinery could not be marketed successfully.

Until the 1940s, the United Kingdom was almost the sole source of technology. In the early 1950s Japan came into the picture as a supplier of technology to the textile industry in Bangladesh and virtually monopolized the market. The entry of India as a supplier in the technology market in mid-1970s somewhat weakened Japan's hold. In the late 1970s and the early 1980s the entry of Romania and other countries further reduced Japan's share. It is argued that the heterogeneity of sources of technology supply is in some respects responsible for the industry's inefficiency (Ahmed and Rahman, 1979, p. 214). For the BTMC, Japan is to date the largest supplier, the U.K. is second, Romania third and India fourth.

During 1908-47, Narayanganj dominated the scene of cotton manufacturing in both spinning and weaving, with about 67% of total capacity. During 1948-71, no new spinning and weaving capacities were installed in the Narayanganj area. The Pakistan government, however, set up new industrial estates in Tongi and Dhaka in the 1950s and in Chittagong in the 1960s. The spindle and loom capacities in and around Dhaka and Tongi grew rapidly to about 25% and 17% for spindles and about 22% and 14% for looms respectively. The growth of cotton manufacturing in Chittagong was impressive. Its share in the total capacity grew from about 6% for spindles and looms in 1947 to almost 25% in 1971. In North Bengal, there was a substantial increase in spindle capacity. North Bengal's share, however, remained unchanged at about 17%, while its share of loom capacity dropped from about 23.5% in 1947 to 12% in 1971. However, after independence of Bangladesh in 1971, the government of Bangladesh made an effort to decentralize the industrial sector, including the cotton textile industry. During 1972-85, almost two-thirds of new mills were set up in North Bengal, which increased its share of spindle capacity from about 17% to 31%, while the shares of the Dhaka and Chittagong districts declined from about 52% to 39% and from 25% to 20% respectively. The remaining 10% of new capacity was installed in other districts. Since 1986, almost all textile capacity has been installed around Dhaka and neighbouring districts. This has somewhat reduced the share of spindle capacity of North Bengal to around 30% of the total.

Bangladesh is well known as a grower of the cotton varieties ab-e-rawan and shabnam from which the fine fabric muslin is made. However, Bangladesh was never a large grower of cotton and depended for its raw material on India before partition and on West Pakistan during 1947-71. Local production in 1987-88 was about 4.95 million kg, and the country imported 58.72 million kg from the USA, USSR, Pakistan, India and other countries in the same year. In a report of the BTMC (1980, p. 3), reduced dependence on external supplies was emphasized as essential for the textile industry to be profitable.

Recent efforts have aimed at reducing the dependence on imported cotton by increasing domestic production. The need to import cotton lays a heavy claim on the country's scarce foreign-exchange resources. The second 5-year plan of 1980-85 ascribed greater importance to the expansion of cotton cultivation and aimed to meet 25% to 40% of requirement through local production. However, only 4.5% of the planned increase was actually achieved at the end of the plan period (1985). The target was too ambitious, as the ideal growing environment for cotton is an arid climate coupled with irrigation; Bangladesh's climate is far different. The third 5-year plan of 1985-90 has retained the target of meeting 40% of requirements through local production. It is very unlikely that such a target will be met during the plan period. Moreover, evidence suggests that cotton cultivation is not an economic proposition for Bangladesh. A report on cotton cultivation (Bangladesh, 1978b, pp. 16-22) suggests that a hectare of wheat saves almost 2.5 times the foreign exchange that a hectare of cotton does.

The mills established before partition were all integrated types and were well known for fine products. About one-third of the fabric produced in the late 1950s was fine and two-thirds medium. During 1961-65, production of fine fabrics declined to about 12%, while that of medium fabrics increased to about 80% of the total. Coarse fabric grew from almost nothing to one-fourth of the total fabric production during the 1960s (Chowdhury, 1977, p. 410).

During 1972-77, the share of fine-quality yarn increased from about 4% to 12%, while the share of medium quality fluctuated between 61% and 77%. The share of coarse-quality yarn decreased steadily during this period from about 29% to 10%. From 1977-78 to 1980-81 the share of medium-quality yarn increased from about 62% to 81% at the expense of finer quality, which decreased from 12% to 6%. Since 1981-82, the production pattern has changed; the share of medium quality decreased from 83% to 76% and the share of fine-quality yarn increased from about 6% to about 10%. It appears that after disinvestment the private sector manufactured a higher percentage of finer yarn than the BTMC.

Medium-quality fabric has dominated in the pre- and post-independence periods. However, the composition of the shares of all types of fabrics during 1972-88 underwent a change. The share of coarse fabrics increased from 1.7% to about 3%, while that of finer fabrics increased from about 0.5% to about 4%. The share of medium-quality fabric, on the other hand, declined from about 90% to 86% during that period (some 7% of production in 1987-88 is classified as "other materials").

The growth of output depends on the installed spindles and looms and the way in which they are used. Table 4 shows that yarn output during 1972-88 increased from 36.27 million kg to 57.88 million kg, an average annual compound growth of about 3.16%. Fabric output rose during 1972-88 from 53.42 million m^2 to 65.77 million m^2, an average annual compound growth of 1.4%, less than that of spinning production.

The cotton textile industry in Bangladesh depends entirely on the domestic market. In 1987-88, almost 65% of the total marketed yarn was provided by the public and private sectors, while imported yarn accounted for the balance. In contrast, state and private mills contributed only about 7% of the total cotton-cloth supply, whereas the handloom industry supplied about 70% and the remaining 23% was met by imports (Bangladesh, 1989a, pp. 595-596).

Since the formation of the BTMC, one of its objectives has been to ensure a regular supply of textile products. Until 1977, the marketing of yarn was mainly through cooperative societies and the Bangladesh Small and Cottage Industries Corporation (BSCIC), whereas fabric was marketed entirely through the Bangladesh Consumer Supplies Corporation (BCSC). However, this system encountered many problems, especially that the handloom weavers continued to pay much more for yarn than the mills did. In 1977, an advisory committee evolved a new system, under which monthly allotments of yarn were made to agencies directly involved with the handloom weavers (BMDC et al, 1979, pp. 1-12). Under this system, the Bangladesh Handloom Board (BHB) was made responsible for the marketing of yarn to an increased number of weavers and tag dealers (government-recognized dealers) became prominent in wholesale and retail yarn marketing. They together marketed about 70% to 80% of the total yarn produced by BTMC. During 1978-88, BTMC's marketing system for yarn went through a number of changes. At present, 70% of yarn is marketed on a mill-contract basis (one agency is given one mill) and 30% through institutional buyers such as government agencies, export-oriented industries etc. All varieties of fabric except drill and celluloid (reserved for the police and army) are on free sale through the BTMC's display centre and different wholesale shops. On the other hand, the private sector markets yarn and fabric directly to the wholesalers at the mill premises. Mill-produced fabrics do not directly compete with handloom product as they are mostly meant for consumers other than those served by the handloom sector (Chowdhury, 1981, pp. 67-70).

The export of yarn during 1972-88 varied from 45 000 kg to 226 800 kg a year. The export market that had existed before independence was based on fine yarn of above-60s count. After the formation of the BTMC, production concentrated on 32s and 40s yarns. Since denationalization of mills, the private sector increased production of finer counts of yarn relative to the proportion that existed during 1972-82. Even now, 32s and 40s yarns dominate production pattern of spinning mills and they together constitute about 75% of production. The industry had no cost advantage in production for export, and product quality was inferior because of inferior raw materials (BTMC, 1981, annex-1).

The output of the textile industry did not correspond with the increase in its capacity because of poor use of spindle and loom capacity. After the formation of BTMC, it was not until 1977-78 that the total yarn output of the industry reached the pre-independence level (1970); this was the result not of any improvement in productivity, but of the already-noted increase in capacity.

Table 4 shows how the capacity use of the spinning sections during 1972-88 varied between 71% and 83%. For the period, the lowest use of spindles was in 1985-86, and the highest level of use was attained in 1982-83. Capacity use in the public sector remained steady; in some years it even increased, whereas in the private sector it fluctuated and remained poor. Thus, the low level of capacity use can be attributed to relatively poor performance in the private sector. The textile industry thus experienced capacity use at least 10% lower than that observed during the Pakistan period; for figures during 1948-66 see Ahmed (1969, p. 126) and during 1967-70 Pakistan (1973, pp. 113-114).

The actual per-shift spindle productivity in table 4 has been calculated from the converted production figures (32s yarn count equivalent) for 1972-73 to 1987-88. During this period, spindle productivity fluctuated from 64.04 g to 73.3 g per shift. Spindle productivity of the industry has been poor despite addition of new spindles, and it did not attain the pre-independence level, 1969-70 (81.44 g). This is due to poorer performance in private mills than in public. During 1972-88, BTMC spindle productivity varied from 66.62 g to 73.42 g, while private-sector productivity remained between 63.78 g and 68.04 g. By comparison, the Indian cooperative textile industry averaged, for 32s count cotton, a spindle production per shift during 1975-80 of 78 g to 86.46 g, which is between 18% and 22% higher than that of the Bangladesh industry (AIFCOSPIN, 1981, p. 35).

Table 4 also shows the productivity of the weaving section during 1972-85. Use of the looms fluctuated between 49% and 77%, relatively lower than the use of spindles. Since the disinvestment in 1982, use fell rapidly, largely because of idle capacity in the private sector. However, during the BTMC period, capacity use for looms underwent a significant improvement from its pre-independence level of 43%. Although, there were significant increases in loom use, loom productivity did not increase. During 1972-78, loom productivity varied from 15.1 m^2 to 18.9 m^2 per shift, whereas the pre-independence level was 23.9 m^2 per shift.

The organized cotton textile industry in 1987 provided about 15% of the total industrial employment of Bangladesh (Bangladesh, 1989a, p. 254). During 1972-84, textile employment increased from 55 780 to 84 970 and then decreased to 67 000 during 1984-88. The decrease in employment was due to the retrenchment of production workers in operating mills and layoffs of workers in closed-down mills in the private sector. The public sector suffers from significant overmanning; the spindle/production worker ratio in the public mills is about 18% higher than in the private mills. During 1972-88, spindle capacity increased by 438 430. Thus employment rose by 1.2% and spindle capacity by about 2.85% annually. In other words, the increase in employment was proportionately less than the growth in spindle capacity. (Loom capacity is not considered here inasmuch as the employment in mill weaving is not of major significance). Table 5 shows that during 1972-88 the number of spindles per production worker and all employees fluctuated between 14 and 23 and 12 and 19 respectively. The spindle ratios per production worker and all employees have been calculated with 1972-73 as the base year (100). For production workers, the spindle ratio steadily increased during 1974-81 from the base year, but during 1982-84 due to re-organization of the industry it fell below the base year. Since 1984, the ratio improved significantly as a result of rationalization of production workers in the private sector. Installation of more spindles than the number of jobs created also contributed to the improvement of this ratio. Improvement in spindle ratio is reflected in increasing output per worker, as discussed below. The spindle ratios for all employees have, however, been below the base year level for a number of years (1972-88). This indicates that the increase in non-production workers was relatively higher than the growth in capacity.

Table 5 shows a steady increase in output per person employed from 746 kg to 1116 kg during 1972-85 but a decrease during 1985-88 varying from 970 kg to 1059 kg. Improvement in the spindle-to-worker ratio had a lot to do with this; it occurred during the BTMC's modernization of existing spindles and addition of new ones. Immediately after disinvestment in 1982, productivity suffered significantly, largely because of low capacity use in the private sector.

The handloom sector in Bangladesh

Handloom weaving in Bangladesh goes back to the 17th century, perhaps earlier. It was an efficient industry at the time and played an important role in the economic activities of the Indian subcontinent. The call of Gandhi under the Swadeshi movement in 1906 to boycott cotton textiles from Lancashire, and the outbreak of World War I, led to the rise of the handloom industry in East Bengal. This led to the growth of such important present-day handloom centres as Baburhat, Tangail, Kamarkhali, Shahzadpur and others.

With the division of the subcontinent at independence, the handloom industry of East Pakistan was confronted with serious problems. The supply of yarn was disrupted, as most of the yarn-producing mills were located in India. The 11 modern textile mills located in East Pakistan were composite ones that had little or no surplus yarn for the handloom industry. Moreover, a large number of the traditional Hindu weavers migrated into India. During the Pakistan period (1947-71), the handloom sector experienced a rapid growth in the early 1950s, with the government lifting import restrictions and abolishing sales tax on yarn. The sector was brought under the East Pakistan Small and Cottage Industries Corporation (EPSIC), which was responsible for yarn distribution to handloom weavers.

However, handloom weavers were always faced with the high price and scarcity of yarn. The survival of the sector, in fact, rested on self-help with little aid from the government. On the other hand, in India since independence the industry flourished with diverse government financial incentives and policies imparting better treatment to the handloom industry than the mill sector (India, 1981, pp. 1-10). After independence, the Bangladesh government set up the Bangladesh Handloom Board (BHB) in 1978 that took over the responsibility for development of the handloom industry from BSCIC. Since its formation, BHB has taken policy measures to develop the industry in line with the Indian textile policy. Handloom is considered a priority for development because of such characteristics as labour intensity, female employment potential, product demand and profitability (BIDS, 1982, pp. 357-361).

Because of the dispersed nature of the handloom industry, different surveys have produced different figures for the total number of handlooms. After Bangladesh gained its independence, BHB with the assistance of the Institute of Business Administration (IBA) undertook a comprehensive census in 1978, which provides essential information on the structure and characteristics of the industry. The 1978 census established total installed handloom capacity at about 437 000, of which two-fifths were idle at the time (Mia, 1979, pp. 16-19). A handloom enterprise survey conducted by Bangladesh Institute of Development Studies (BIDS) in 1987 estimated the number of looms to be 425 300; however, the level of use of this capacity was found to be higher (three-fourths) than the 1978 census (Latif, 1988, pp. 95-108). For administrative purposes, the country has been divided into four divisions. According to the 1978 census, in the Dhaka division there are 183 612 looms, of which 116 002 are operational and 67 610 are idle. The Rajshahi division has 105 300 looms, of which 63 148 are operational and 42 152 are idle. Chittagong has 83 136 looms, 48 489 operational and 34 647 idle, and Khulna has 64 967 looms, 32 282 operational and 32 685 idle. Thus only about 59% of handlooms are operational. This low usage can be attributed to shortages of working capital and raw material and some seasonal variations in demand. It is to be noted that the Dhaka division, which has the leading share of looms, also has a higher usage -- Rajshahi and Dhaka divisions have usages of about 67% and 63% respectively, whereas Chittagong is third with 58% and Khulna has 50%.

The size of the units varies according to location. Rajshahi has the highest number of total looms per production unit (3.34) followed by Dhaka (2.68), Chittagong (1.93) and Khulna (1.70). The national weighted average size of production units for total and operational looms are 2.30 and 1.36 looms respectively.

Handlooms are traditionally household units. It appears that the handloom industry is dominated by unit sizes of up to five looms; 72% of the total looms fall under this category. Units with 6 to 10 and 11 to 20 looms account for 11% and 6% of the total loom capacity. Units with 21 or more looms are considered small factories; they constitute about 11% of handloom capacity.

A 1982 enquiry by the Ministry of Industries, however, shows that small factories have 20% of handlooms (Bangladesh, 1982b, pp. 18-19). The small factories have no problems of capacity use, given their size, and their working-capital problems are fewer than those of the small household units; also they purchase raw material in bulk at very competitive prices. With low overhead costs, division of labour and better marketing facilities they are more economic than the individual household units.

The 1978 census identifies four kinds of looms: pit, pit-throw, fly shuttle and CR (semi-automatic). The pit-loom accounts for about 62% of total capacity, followed by CR, which accounts for about 23%. The other two loom types together share about 15% of capacity. Ninety percent of the looms of Khulna and Chittagong are pit, while, in Rajshahi, CR-looms comprise 59% of total capacity. In Dhaka division, the share of pit-loom is just over 50%.

Handloom technology in Bangladesh has remained unchanged over the decades, with little improvement. One of the reasons for low productivity of this industry is its rudimentary technology. Unlike Bangladesh, India has made substantial technological improvements to the old looms and has also developed new ones. There are at least 38 different kinds of looms at present in the Indian handloom industry (Ramamurthi, 1981, pp. 1-3).

Although handloom weaving is carried on throughout the country, it is traditionally concentrated in a few districts -- mainly Dhaka, Pabna, Comilla and Tangail -- in which there are about 70% of the installed looms and more than 79% of the total operated looms. Dhaka accounts for about 33% of the total operational capacity and about 35% of total employment. The next two important centres are Pabna and Comilla accounting for 22% and 16% of the operational capacity respectively. Dhaka has long been established as an important centre for handloom industry because of its skilled craftsmen and specialized products and continues to play a leading role (Routh, 1981, p. 3).

According to the Handloom Census of 1978, the handloom industry uses 93.3% cotton yarn and 6.7% cellulose, synthetic fibres and other types of yarn. However, in recent years, synthetic yarn is becoming popular among the handloom weavers, as it is less vulnerable to end breakage. The finest yarn that can be woven on a handloom ranges from 10s to 100s count, which is what the Indian industry produces (Srikantaiah et al, 1978, pp. 4-7). The

Bangladesh handloom industry, however, uses yarn between 10s and 80s count and commonly specializes in medium quality fabric.

The Handloom Census shows that handloom consumes about 71% medium, 16% coarse, and 7% fine qualities of yarn and about 6% of other types. It also appears that Dhaka, Chittagong and Khulna divisions mainly specialize in medium quality fabric, whereas Rajshahi (North Bengal) produces finer quality. This is a shift from the pre-partition position, when North Bengal specialized in coarse to medium-quality fabric (Routh, 1981, p. 4).

Traditionally, the handloom industry depends on the mills for its yarn supply. Handspun yarn, which constitutes only 0.15% of total yarn production, is consumed locally (Bangladesh, 1981a, p. 10). The textile mills, which have a small weaving capacity, sell their surplus yarn to the private modern weaving and handloom sectors. But the yarn produced domestically is not sufficient to meet the demands of the handloom sector. In 1988 about 35% of yarn requirements for handloom was met through imports.

The handloom industry mostly produces coarse to medium fabric, but there are still a few pockets of weavers left who produce muslin, jamdani and other fine material for a small section of Bangladesh society and for export. Handloom fabrics, except for grey material, are mostly cloth pieces such as sari, lungi, gamcha, chaddar and other types, ready to be worn right after weaving. The product mix varies according to the location. For example, Pabna district specializes in sari pieces, whereas Comilla and Chittagong are well known for lungis.

Table 6 shows that sari is the most important product (about 48%) followed by lungi (about 31%). The remaining 21% is distributed among gamcha, chaddar and others. About 73% and 83% of the handloom production of Rajshahi and Chittagong divisions are sari and lungi respectively. The handloom output has varied from 372 000 000 m^2 to 813 000 000 m^2 between 1973-74 and 1987-88 (Table 7).

About 98% of all handloom products are marketed in weekly open markets known as hat, and about 2% through cooperatives or other associations. Long-channel intermediaries create a price differential of 30% to 40% between the weavers and the ultimate consumers (van Leeuwen and de Ruiter, 1982, p. 72; Bangladesh, 1982b, p. 71). It is the intermediaries who make the most of the profit, while the weavers find it difficult to meet production costs.

Handloom weavers receive institutional support mainly from cooperative associations, BHB and some non-government organizations.

About 79% of weavers of Bangladesh are members of Cooperative Industrial Unions at district, sub-division or thana levels. These are organized at the national level by Bangladesh Jatiya Samabay Samity Ltd (BJSS). Their main function is to provide purchasing and marketing facilities to the member societies. Although the coverage of handloom under cooperatives is evidently higher than in India (India, 1974, pp. 9-10), in Bangladesh little more than 2% of the weavers enjoy any services from these societies (Maldonado, 1976, p. 10; Miyan, 1979 pp. 104-106; Bangladesh, 1982a, p. 20).

The Bangladesh Handloom Board was formed to identify the problems and the scope of future development of the handloom industry. Although such development measures as marketing, distribution and financial support to the handloom weavers were pursued by the board, they met with little success. A report of the Dutch government on the Bangladesh handloom industry emphasized that the board organization is too weak to be entrusted with the massive task of developing this sector (van Leeuwen and de Ruiter, 1982, pp. 10-11). Subsequent study by BIDS (Bhattacharya, 1988, pp. 1-4; Bangladesh, 1988a, p. 30) also confirms the weak structure and poor implementation of projects by the board.

The handloom census established that the sector directly employs about 876 000 people; including ancillary employment it would be more than a million. The possibility of further employment was emphasized in a report of the government's Planning Commission (Bangladesh, 1980b, pp. 2-8). The employment involves family members or hired help on either a regular or casual basis. Most family members, sometimes even the very young (7 or 8 years) are able to contribute to the cloth making. Family members constitute about 58% of the total employment, while hired workers, regular and casual, constitute about 30% and 12% respectively. The national weighted average employment per loom is 3.31, which comprises family and hired labour of 2.0 and 1.3 persons respectively.

According to the handloom census, the productivity of weavers can be calculated as 12.30 m^2/d. This estimate, however, does not account for different loom types and seasonal variations. Another estimate could be made from the Statistical Year Book (Bangladesh, 1989a, pp. 595-596), where production is based on the total yarn consumption of the handloom industry. According to this, productivity is 10.24 m^2/d, based on 250 working days annually, which is only about 83% of the first calculation. But this estimate does not consider loom types and cloth construction. A survey undertaken by the author for this study of 214 household weavers takes into account seasonal production variation, cloth construction and different loom types and shows the loom or weaver productivity for pit- and CR-looms as 7.96 and 10.33 m^2/d respectively. If the proportion of pit- and CR-looms in the total capacity is considered, the weighted mean productivity of the handloom is found to be 8.62 m^2/d.

The problems

The cotton textile industry in Bangladesh is characterized by low productivity deriving from underuse of capacity, use of old equipment, poor management and poor organization.

Although labour productivity increased during the BTMC period, spindle and loom productivity remained low (BTMC, 1980, pp. 1-10). Spindle productivity during 1972-88 did not reach that of the preindependence year in spite of the addition of new and modernized spindles; productivity in 1988 was about 89% of the 1970 level and capacity use was 79%. Loom productivity also decreased during 1972-88, it had fallen to almost 72% of the pre-1970 level. By 1988, however, capacity use in weaving increased from its pre-1970 level by about 43%.

The low productivity of spindles and looms can be ascribed to the age of the equipment. About 6% of the spinning equipment is of 1923-47 vintage and about 60% is of 1948-71 vintage (78% of this was installed during 1960-65); about 34% of the additional new capacity was installed during 1972-88. About 30.5% of weaving capacity belongs to the 1923-1947 vintage, 64% to the 1948-1965 vintage and 5.5% to new capacity (1970-84).

Power failure also appears to have been a major reason for low productivity. During 1980-88, between 4% and 14% of total spinning and between 2% and 9% of weaving production hours were lost through power failure.

The handloom sector, too, suffers from low productivity and underuse of capacity. Here, only 60% of the total capacity is being used. This is largely because the handloom technology used in Bangladesh remains somewhat crude, while no effort has been made to change the design of the looms or increase weaver productivity. On the other hand, considerable progress has been made in India. Although India started with the same basic loom technology, it has, since independence, diversified into different kinds of improved handlooms. Above all, it has developed an integrated network of institutions, such as the Weavers' Service Centre, Apex Marketing and other societies and a special Institute for Handloom Technology (India, 1981, pp. 1-10).

Other important elements that have been the focal point in many studies are the channeling of yarn to the handloom weavers and marketing of their products. The present channel of marketing both yarn and fabric has proved inefficient and provides opportunities for the middlemen to make an enormous profit. The task-force report (Bangladesh, 1982b, pp. 44-45, 61-63) asserts that the present marketing system exploits weavers through a larger margin of profit for dyeing and higher interest rates (sometimes up to 200%) for credit selling. A study conducted by BIDS (Islam, 1989, pp. 55-65), however, found that rates of interest for credit purchase and credit dyeing vary with unit size, volume of purchase and source of procurement, and the interest can be up to 90%. The shortage of working capital is said to be the major problem. It has been argued that weavers with sufficient working capital are able to operate independently and exert more bargaining power in selling their products. This will reduce the exploitation of the weavers by the middlemen and the "mahajans". The need for improvements in productivity, technology, product development and marketing for a viable handloom industry was emphasized both in a report for the Netherlands government (van Leeuwen and de Ruiter, 1982, pp. 2-8) and in the government's own textile policy document (Bangladesh, 1988a p.28). Without such improvements, the country's cloth requirements will remain far from being met by the handloom industry.

Output and consumption

Table 7 shows production and imports of cotton yarn and cloth and per-capita consumption. In 1987-88, an estimated 20.1 million m^2 of synthetic cloth was also produced -- about 0.19 m^2 per capita. Even though there was an increase in yarn production, it failed to meet the handloom yarn requirement. Therefore, the supply gap had to be met by importing yarn and cloth.

About 2.62 million spindles and 28 000 looms would be required if the entire per-capita target of 10.97 m^2 of cloth set by the third 5-year plan were to be supplied domestically by 1990. This would entail doubling the present number of spindles and quadrupling the present number of modern looms.

If the number of modern looms is not expanded, any increase in domestic cloth supplies will have to come through handloom expansion. The additional handloom capacity required to attain the 10.97 m^2 target varies from about 303 000 to 377 000 depending on loom productivity. Of the total handloom capacity of 437 000 now installed, 177 000 are idle. Even after bringing all these idle handlooms into operation, 126 000 to 200 000 handlooms would additionally be required to meet the target.

Population and employment

The rate of growth of GDP for Bangladesh from 1972-73 to 1987-88 fluctuated between 1.2% and 9.6%. However, per-capita growth was less, ranging from -1.2% to 6.9%. Real per-capita income rose from BDT 612 to 802 and so showed an average annual compound growth rate of 1.82%. The population census of 1981 shows that during 1971-81 the average annual increase in population was 2.6%, which gave rise to an annual increase in the labour force of 3.1%.

There are many projections of population, based on different assumptions. Skutle and Tveite (1981, pp. 2-3) suggested that estimates for the year 2000 vary from 100 to 160 million, but that 117 million should be regarded as the lowest possible estimate and 160 million as the highest. They propose that for practical planning purposes, 134 million be accepted as a reasonable compromise. Here it is convenient to use the projections made by the World Bank (IBRD, 1980, p. 79. table 1.1C, 1983, p. 110. table 1.5), because it estimates a population of 134 million in 2000 and also relates population growth to that of the labour force (Table 8).

The World Bank projects that the labour force will continue to grow -- by more than 3% a year -- even after population increase has slowed to an annual rate of 1.5%. Employment in these circumstances will be more difficult to find. In this regard it is appropriate here to refer an example put forward by Todaro (1980, pp. 204-207), who suggests that a developing country whose modern industrial sector employs 10% to 20% of the labour force would need to increase employment by 15% a year just to absorb the increase in a total work force growing at 3% a year. This illustration has particular relevance to Bangladesh, where about 58% of the people are directly employed in agriculture, 11% in manufacturing and 31% in services. The growing labour force therefore needs to be accommodated in the non-agriculture sector.

With slow growth in agricultural output and employment, manufacturing industry must play an important role in generating employment. This directly brings forward the issue of technology in the manufacturing sector. Uncritical choice of modern technology is often in conflict with employment generation, which is essential for continuing economic growth with equity. Present emphasis in 2-year and 5-year plans (1973-90) is on optimum use of labour in relation to scarce capital. The use of local labour has been advocated; it has been argued that it should not be replaced by scarce capital if it can be avoided (Bangladesh, 1973, pp. 17-21; 1978a, p. 149; 1980a, p. II-7; 1985b, pp. 108-109).

Textiles, one of the largest manufacturing industries, could play an important role in generating employment. Calculations indicate that to meet the 1990 target of 10.97 m^2 of cloth per capita by handloom only, Bangladesh would need to bring into operation another 200 000 handlooms. If the cloth requirements are to be met by domestic production using modern technology, the country would have to set up about 60 composite (spinning and weaving) units with 1 500 000 spindles and 28 000 modern looms, which would create direct employment for more than 90 000 people.

With such a possibility, the choice of technology would certainly play an important role in providing optimal employment in the textile industry (Pickett and Robson, 1981, pp. 8-9). Moreover, there is a number of alternative production technologies to choose from, ranging from simple hand spinning and handlooms to the highly sophisticated open-end spindles and shuttleless looms (Catling, 1984, pp. 1-4). A product could be manufactured either in a small factory unit (decentralized sector) or even in a cottage-type unit (traditional sector) without much affecting its quality. However, the employment created by these alternative methods would vary to a large extent. Pickett and Robson (1979, pp. 31-35) show that annual production of 23 400 000 m^2 of cloth could employ 1245 to 48 000 people according to the technology chosen.

Therefore, a detailed study of this industry with special emphasis on methods of production and their implications for employment could be of immense interest to economic planners. Such an exercise would examine present policy and, one hopes, lead to the formation of policies for expansion and development of the textile industry.

Expansion policy

All 5-year and the 2-year plans aimed at expanding output of essential items such as food and clothing. The major activity of the modern sector of the textile industry is production of yarn, much of it for the handlooms of the traditional sector. All the development plans of 1973-90 have restricted expansion of modern loom capacity to encourage handloom production.

The Bangladesh government has regulated the weaving capacity of the BTMC almost to the 1970 level, so the corporation's expansion possibilities were limited to spinning. Private-sector textile activities were restricted to non-cotton cloth production until 1982; thereafter, the private sector was allowed to undertake only cotton-yarn production.

The encouragement of handloom weaving is largely based on the argument for employment generation. But this policy bias in favour of handloom can hardly be sustained on efficiency grounds, as I show in chapter seven.

Chapter Three

Evaluating technology

To choose appropriate technology systematically requires that alternative production techniques be examined technically and economically. The method will identify and cost the techniques, a form of appraisal known as discounted cash flow (DCF).

Identification

Alternative production methods can vary in technology and organization. Modern production methods are adopted by large factories, but they can also be used in the small-scale, decentralized sector. It is, however, assumed that the decentralized sector would use an intermediate technology developed in India. Finally, handlooms are located in rural households and would be under the traditional sector. A complete textile process that has grey cloth as its output consists of several subprocess operations -- opening and cleaning of raw material, carding, drawing, roving, spinning, cone-winding, pirn winding, warping, sizing and weaving (see chapter four and glossary).

In modern textile technology there are two kinds of spinning -- ring-spinning and open-end spinning. The weaving technology varies from the ordinary Lancashire, automatic, battery or unifil, to the pirnless loom -- airjet, rapier, projectile or multi-shuttle. These different technologies have a range of operating speed. Ring-spinning, for example, has a maximum spindle speed of 30 000 rpm, whereas open-end spinning can have a rotor speed up to 120 000 rpm. In weaving, an ordinary Lancashire loom can have a weft insertion of 7.67 m^2/s, whereas an airjet machine is three times as fast. It is evident that different technology and employment levels can be combined (Pickett and Robson, 1979, pp. 5-8). Earlier studies suggest that such combinations are likely to suit developing countries. In the modern sector, the options can be machinery from either different sources or different subprocesses. Thus technologies from Japan, Romania, India and the United Kingdom can be combined.

The concept of intermediate technology is not very clear. Some authors (Boon, 1979, pp. 69-73) have suggested that this technology needs to be developed to accommodate the factor proportions and prices of the developing countries. Pack (1976, pp. 153-173) argues in favour of the use of second-hand machinery as an alternative to intermediate technology. For the present purpose, intermediate technology may be defined as technology that is basically a rebuilt conventional one and at present available in India. Also, some manufacturers produce older versions of new machines for small-scale operations. The other type of intermediate technology developed by the Appropriate Technology Development Association (ATDA), India (Garg and Bruce, 1978, pp. 9-10), is a completely new range of machinery that could be available for small-scale operations. A spinning technology, which is widely in operation in India and could be identified as a type of intermediate technology, is that widely promoted by the Khadi and Village Industries Commission (KVIC, n.d., pp. 4-22). The KVIC technology is cottage-type and used in small factories in India.

Handloom weaving is mostly organized in cottage units and is a formidable industry in India and Bangladesh. Traditionally, the yarn requirement of this industry is supplied by hand spinning. However, with the advent of modern spinning, the role of hand-spinning has diminished considerably. It supplies about 1% of the total yarn production in India and less than 0.5% in Bangladesh. The types of handloom vary considerably; as suggested earlier, there could be as many as 38 different varieties of handloom in India. The types found in Bangladesh are mainly four -- semi-automatic (CR), fly-through, fly-shuttle and pit.

Costing of technologies

A detailed costing of the alternative processes is important for the microeconomic search for technology. Pickett and Robson (1981, pp. 32-43), Pack 1976, pp. 156-162) and UNECLA (1966, pp. 16-32) have emphasized that a microeconomic search should combine input costs, wastage level, skill composition and other factors to arrive at an economically defensible choice. Essentially this cost could be broadly divided into investment and operating costs.

Investment cost comprises the costs of machinery and installation, buildings and infrastructure, working capital and some contingency for unforeseen expenditures. Machinery cost can be cost, insurance and freight (CIF) and ex-factory, depending on whether the machinery is imported or locally purchased. Duties and taxes can form a component of machinery cost. For instance, if the evaluation is a financial one, taxes and duties need to be taken into consideration, whereas for an economic analysis all taxes and subsidies would have to be excluded. Transport cost depends on the location of the plant -- if for example, the plant is located near the coast, there would not be any transport cost for imported machinery, although there might be for locally manufactured machinery. For the rural sector, the machinery would not have any tariff component, and the transport cost of these technologies could also be minimal.

Building and infrastructure costs could vary according to the technology. For the modern sector, buildings usually are constructed with concrete foundations, floors and roofs and brick walls. For a small-scale factory, as observed in India, construction could be the same but with a tin roof. The type of construction of the floor and the width of the wall could also vary. Handlooms are mostly set up in houses without concrete floors but with thatched or tin roofs. Another important aspect of building cost is the floor-space requirement, which varies for different technologies.

The need for working capital depends on stocks of raw material, material in the processing stage, finished goods, spares and accessories and cash in hand. The working capital needed for modern, intermediate and traditional technologies may not be the same. Contingencies and other costs involve miscellaneous expenditures due to unforeseen factors.

Operating cost consists of the costs of raw material and sizing materials, labour, fuel and power, spares, repairs etc. The raw-material cost could vary according to the amount of waste that each technology produces. For a composite unit, the raw material is raw cotton. This is CIF cost, as more than 95% of the total supply of raw cotton of the country is imported. In addition to this cost there are landing and handling charges, transportation and other costs depending on the location and the type of evaluations to be carried out. For handlooms, the input cost is yarn at ex-factory cost including taxes and distribution cost and possibly also profit. The cost of sizing for composite units and handloom is likely to vary for the two sectors.

Wages are an important element of operating costs. Wage costs usually vary with productivity and skill. It is be easier to identify skills composition in the organized sector, where wages are determined according to skills. These wage rates can be used for alternative technologies in the modern sector. The wage rates of intermediate and KVIC technologies can be estimated by determining the skill level for each subprocess and applying modern-sector wages. In determining skill levels, consideration should also be given to an operative's productivity. This is so as the nature of intermediate technology limits operatives to work on fewer machines than in the modern sector, irrespective of their levels of skill. Wage rates for hand spinning and handloom weaving may be derived from known rates in these sectors. For an economic appraisal, if the wage rate of skilled labour reflects the opportunity cost, it is necessary only to derive a shadow wage rate for unskilled labour.

The salaries paid at different levels of management in the organized sector are known. This salary structure can be applied in the intermediate sector provided the level of management skills can be established. What level is applied will depend on the size and organization of each unit and the number of employees. Administrative overheads, repairs and other miscellaneous costs also need to be taken into account to arrive at the total operating cost.

The cost of power is more significant than that of fuel; it may vary across alternatives within modern and intermediate technologies, the latter consuming less power. On the other hand, the traditional sector does not consume any power.

The cost of spares also varies across different technologies, and it can be reasonably assumed that spares for modern machines are imported, whereas for intermediate technology they may be locally available. These costs can be CIF or ex-factory, plus additional costs such as landing and handling charges, transportation, and duties and taxes, according to circumstances. Spares for handlooms and preweaving machinery are locally made and available at market price and do not include any transportation cost.

Evaluation by a discounting appraisal

Technology choice requires a complete specification and costing of the alternatives, together with a method for selecting among the mutually exclusive, alternative technologies. If investment is regarded as a choice between the present and the future, it follows that a discount appraisal is the most appropriate method. The discount rate to be used should reflect the true cost of capital. This poses a problem in the case of developing countries where the market mechanism is not developed. In such an instance, it is convenient to use different discount rates to show sensitivity to changes in the discount rate. A beginning rate can always be found by taking the rate of return obtainable from money lent abroad.

Many investment criteria are in use. Two frequently used that are relevant here are net present value (NPV) and internal rate of return (IRR). NPV is the sum of the discounted difference between operating cost and revenue generated by a project during its lifetime, whereas IRR is the rate of discount that would make the NPV of the project zero. In other words the NPV gives net surplus, while the IRR gives the difference in the rate of return over the cost of the capital in the life time of the project.

The NPV and the IRR are related and each would provide a measure as to whether to accept or reject a project at a given capital cost. However, they would give different rankings in a series of mutually exclusive projects. It would be required in the present context to make a choice among the criteria, and economists generally prefer to choose NPV for measuring profitability when the emphasis is on maximization of surplus at a given discount rate.

For the present purpose, it would be befitting to extend the measure of choice using the discounted cash-flow appraisal method. Such criteria could be used to assess, in addition to profitability criteria (NPV), the present value cost (PVC) of alternative technologies and the present value cost per unit of output (PVC/unit). Both these measures are widely used by the David Livingstone Institute (DLI) method of appraisal to identify least-cost technology and in several studies related to the choice of techniques (DLI, 1975, pp. 32-55). PVC essentially discounts all the cost elements of the project to their present value at a given rate of discount, while PVC/unit only decides the PVC by the annual or total output.

Data requirements and problems

To facilitate combining of alternative technologies, detailed technical information and economic data are required. These data include machine prices of alternative techniques and their production capacity, manufacturer's recommended or expected efficiency, power input, wastage level, floor space, manning requirements etc. For the modern sector, this information can be found from manufacturers' price quotations and technical literature, but for intermediate and traditional technologies the information is less readily available. For instance, some machines are rebuilt from old ones for specific purposes. To make reasonable estimates of cost, therefore, it was at times necessary to have direct, detailed consultation with the machinery manufacturer. However, prices and technical details are readily available for some machinery such as devices for ring spinning, section warping and pirn winding or the pedal- and power-looms. Handlooms and preweaving machinery in the cottage sector do not have any organized market; in fact these are mostly built by local carpenters and tinsmiths. The prices of such machinery vary considerably, as does its useful life, which is an important element in pricing. A field observation is essential to estimate prices of this machinery.

Data on machine productivity and manning are very important. The available literature only suggests rated and expected production and manning requirements. However, this information is not country-specific. Specific country data are required to estimate machine and labour productivity. When machines of different types or origins are used, each may have a different productivity and manning level, a factor that should be taken into account. Another problem may arise from the fact that the data available may include machinery of older vintage, when ex-ante evaluation of alternatives considers the prices and rated and expected production of new machines. Therefore, the direct use of data for currently practiced technology may not be appropriate. For intermediate technology, this problem is not so significant, as only rarely is an increase in production the result of technical progress. A careful observation of the practiced technology, however, is needed to estimate production levels, manning requirements, power consumption, wastage etc.

The formidable problem arises when estimating the productivity and input costs of the handloom industry. Productivity may depend on the type of equipment used, seasonal variations and local characteristics of the industry. Input costs may vary according to location, market accessibility and the availability of working capital. All these need to be taken into account when establishing productivity levels and input costs.

Maintaining machinery -- and the cost of doing so -- may vary according to the technologies. Modern machinery, for example, requires a regular maintenance schedule that will prevent breakdowns, whereas intermediate technology may need maintenance only when there is a breakdown. On the other hand, there is little maintenance for the traditional technologies. Therefore, a detailed knowledge of the maintenance system and types of repairs is essential to estimate maintenance cost.

Chapter Four

Options, sources and parameters for the evaluation of alternative technologies

Any visitor to just a few textile mills can see that there are different techniques in use. In some countries, including Bangladesh, hand spinning and -- more widely -- handloom weaving are to be observed. Even within the modern sector, alternative techniques are numbered by the thousand (UNECLA, 1966, pp. 4-5; Pack, 1976, pp. 155-156; Pickett and Robson, 1977, pp. 203-208; 1979, pp. 28-30, 1981, pp. 66-70; Boon, 1979, pp. 69-73). As a consequence, one problem in a study of techniques is that of keeping the number of alternatives manageable.

Subprocesses

The making of cloth begins with ginning, a mechanical operation that separates the cotton from its seed. The cotton is delivered to the mill in bales. It then passes through a number of operations, which may be grouped as follows:

Stages	Subprocess	Product
I Spinning preparation	Opening and cleaning, carding, drawing and roving	Roving
II Spinning and ring finishing	Spinning, cone-winding, reeling, bundle pressing and bailing	Yarn in bales
III Weaving preparation	Cone winding, pirn winding, warping, sizing and drawing-in	Yarn beam and weft pirn
IV Weaving and bailing	Weaving, cloth checking and folding and bailing	Fabric in bales

The above four stages of production process are discussed in detail below:

Stage one

Opening and cleaning

The object of the opening and cleaning process is to blend cotton so as to get a uniform raw material, clean it (that is remove leaf, dirt and trash), open up the fibres, as these have been compressed in bales, and deliver a cleaned, uniform product in a suitable form to the next stage. Opening and cleaning take place in the blow room and involve a range of four or five machines. These comprise an opener, mixing and cleaning machine and a scutcher. The opening machine involves, inter alia, beating the cotton in such a way that loosened extraneous matter is disposed of through a suitably located grid. The cleaning machines make use of combing and beating further to purify the cotton, which emerges in lap form. It is then fed to the scutcher which comprises a rapidly revolving , multi-bladed beater mounted over a grid. The cotton passes under this beater, is still further loosened by suction, and is delivered as a continuous flat sheet (or lap) of uniform thickness, which is made into a large roll to be fed to the carding machines.

Carding

The carding machine removes most of the remaining impurities from the cotton as well as relatively short fibres left in from the previous process. It also breaks up any hard tufts that have survived the earlier opening and cleaning operations. At this stage a basic objective is the formation of a sliver so that the machine further attenuates the material, the actual draft (from lap to sliver) being about 100. The lapped cotton is collected by rollers and narrowed to a thick sliver, which is coiled into tall, narrow card cans.

Drawing

The draw frame draws several slivers from the card cans and attenuates them to the dimensions of one thus increasing the uniformity of the product. The draw frame uses pairs of rollers in line and suitably spaced so that the differential speeds of the rollers attenuate the fibres without causing them to break.

Roving

The object of the roving frame is further to attenuate -- the actual draft being about seven -- and even the sliver, which at this stage requires some twist to give strength, and to wind it onto bobbins suitable for spinning. Use is again made of rollers.

<u>Stage two</u>

Spinning

Two main types of spinning are used: ring spinning and open-end or break spinning. This study is concerned with ring spinning. In ring spinning, bobbins of roving are placed on the upper part of the ring frame. The roving -- a sliver of the thickness of coarse string -- is led downward through drafting rollers onto a vertical spindle, which rotates at very high speed. A light ring round the spindle is fitted with a traveler, and the roving from the drafting rollers is threaded through a small yarn guide vertically over the spindle through the traveler to the spindle. The traveler imparts a slight drag to the roving, and this has a tensioning effect as the roving is guided round the spindle. This effect facilitates the twisting and operation.

Cone winding

The purpose of cone winding is to rewind the yarn obtained from the spinning frame on to a larger package, say 10 times as large, and at the same time to remove faults so as to facilitate subsequent processing. The subsequent processes are rewinding onto pirns for weft (for shuttle) and warping for preparing a beam for loom which is to be used for weaving.

Reeling, bundle press and bailing

Reeling, bundle press and bailing operations are performed only if the output is yarn and it is marketed in this form. The objective of the reeling is to transfer yarn either from spinning (in cop) or from cone winding (in cone) onto a circular machine to form hanks. These hanks subsequently are formed into a bundle of about 5 kg by a bundle-making machine. Several bundles (about 40) are used to form a bail. The operation is known as bailing and the machine used is a bailing press.

Stage three

Pirn winding

Pirn winding is necessary for conventional weaving but can be avoided in case of shuttleless weaving and direct spinning onto the pirn. Alternatives considered in this study will require pirn to weave cloth.

Warping

The object of warping is to prepare a package suitable to feed the subsequent process of sizing. The package prepared (back beam) contains usually from 400 to 600 ends of yarn drawn from the corresponding number of cones mounted on a creel. The length of the individual threads depends on the size (diameter) of the beam and 20 000 m to 40 000 m is usual, so that the weight of a beam may be as low as 500 kg or as high as 1500 kg, depending on the count of yarn.

Sizing

At this stage the objective is to size the warp threads so as to reduce the effect of friction on these as the shuttle, healds and reeds are activated during weaving. This reduces breakages at the weaving stage. Once sized, the threads are assembled onto a weaver's beam. After sizing, the threads are separated by the lease rods of an expanding comb.

Drawing-in

The final stage in warp preparation is the drawing-in of the sized warp threads through the healds, reed and drop wires of the loom. Drawing-in is a complicated process and tying-in of a similar warp is always preferred. Drawing-in and tying-in can be done mechanically but in Bangladesh are usually done manually.

Stage four

Weaving

In weaving, the warp and the weft threads are interlaced. This gives the fabric strength and compactness as well as a measure of elasticity. It is achieved by three basic motions: shedding, picking, and beating-in. Associated with these three motions are three corresponding devices: the heald, the shuttle, and the reed. The prepared warped threads are placed on a beam at the back of the loom and drawn from this across the loom from back to front to be placed on the cloth roller. The warp threads are supported back and front and each thread is passed through the eye of the heald. The healds -- in two sets -- are attached to a roller at the top of the loom and treadles at the bottom. Movement of the treadles causes one set of healds to be raised slightly and the other (alternating) set to be depressed slightly. This causes the corresponding two sets of warp thread to diverge and thus form a shed. Weft thread (contained, say, in a shuttle) is now impelled from one side of the loom to the other in the picking motion. Next the healds change position to from a fresh warp shed which encloses the pick just formed. The reed, which lies parallel to the weft, is now impelled forward to beat in the weft to similar threads previously inserted in similar fashion. When this motion is completed, the weft (shuttle) is shot back across the loom, the healds change to form another new shed and beating-in again takes place. In this way, the cloth is steadily woven and it is slowly wound onto the cloth roller.

Cloth checking and folding and bailing

These operations are known as weaving finishing. After the cloth is woven, the quality of cloth is checked by laying it on a table. The operation is known as cloth checking and folding. A determined length of folded cloth is used to form a bail by a bailing press.

These stages of production are strictly maintained if the yarn or fabric is being produced in a modern textile factory. But in a small factory or in hand spinning and weaving, some of the processes are excluded, for example cone winding. The complete processes for the organized, decentralized and traditional textile sectors are shown in Fig. 1.

My determination of alternative techniques based on these four stages of production is somewhat similar to the method of Pickett and Robson (1977, p. 205). This method separates the textile process into four stages of production and then replaces each stage in an orderly progression by conventional, intermediate and automatic technologies.

The stages of production in the present study are based on the combination of modern, intermediate or traditional technologies. There are as many as 66 technically feasible techniques that can be identified and are at present in use in some form in India. However, the present study evaluates the 12 most commonly practiced technologies under Bangladesh conditions. The alternative technologies are shown in Fig. 2.

Spinning and composite technologies are both in operation in Bangladesh. Spinning technology combines the first two stages of production -- preparatory spinning with spinning and ring finishing -- to produce yarn as an intermediate product. The composite unit combines all the four stages of production. These complete process technologies are embodied in machinery and equipment of different origins -- the United Kingdom, Japan, Romania and India. Four modern alternative technologies are shown in Fig. 2.

Modern spinning can be combined with the traditional handloom weaving. Adhyaru et al (1979, pp. 41-61) and Sabhaney (1979, pp. 37-40) and others have suggested that this combination will sustain the present employment level of the rural sector. Such a combination can be achieved with alternative sources of spinning machinery, technical features and labour complements. Ideally, the best combination of technology would be the most efficient spinning technology combined with handloom weaving. More alternatives can occur with the four main types of handloom found in Bangladesh (chapter two). Also, choices are available among preparatory weaving processes at the cottage level. Small units with 1-2 looms usually conduct their preparatory processes at home, mainly with the assistance of family labour, whereas in units with more than two looms warping and sizing is subcontracted. The latter method was found to be quite popular and has therefore been considered as an alternative. Alternatives (technology five and six) combining modern, least-cost spinning and two types of handlooms are shown in Fig. 2.

One combination is to replace preparatory weaving at the cottage level by a small-scale factory operation -- a Service Centre (SC). In this mode, winding, warping and sizing are combined to supply warp beam to the handloom weavers. This alternative was first introduced by the Appropriate Technology Development Association (ATDA), India, which asserts that it could save at least 20% to 22% of the preparatory cost for the handloom weavers (Garg and Bruce, 1978, p.10). It supplies yarn beam to the weavers who use ATDA-developed pedal-looms. Similar methods in practice in South India are being organized by the Khadi and Village Industries Commission (KVIC), under what is known as the Loke Vastra scheme to produce cheap cloth for the people.

In Bangladesh, service centre type facilities are extended to the handloom weavers under the Bangladesh Handloom Board (BHB). However, the main help provided is for fabric finishing. The SC combination has some operational constraints in Bangladesh because of the kind of looms there. The pit- and CR-looms are equipped with smaller beams that carry a much shorter length of warp than pedal-looms. Therefore, an additional operation is required to transfer large-beam into smaller-beamwarp, but this would reduce sizing efficiency drastically. An alternative (technology seven) combining modern least-cost spinning, service centre and handloom is shown in Fig. 2.

Decentralized spinning, as defined in India, does not exist in Bangladesh. In South India, production units with up to 1000 spindles are in operation -- it is technically possible to increase the number of spindles to 5000 or 6000. Decentralized textile production in India can be categorized into the ATDA roving-centre technology and the Rural Fabric Centre (RFC) technology. The ATDA suggests that by developing a technology to supply roving and processed warp beam to cottage spinners and weavers, the yarn cost will be reduced by 16-22%. The ATDA has an experimental unit that has been working since 1978 in Uttar Pradesh, India. This centre uses rebuilt machinery to produce roving and a separate weaving preparatory unit to produce warp beams. The ATDA has developed spinning frames and pedal-looms that are available to cottage spinners and weavers for a low deposit and small monthly payments. The spinning frames have 12 spindles and are either power-operated or pedal-driven. Frames can be connected to form a single spinning frame of 24, 36 or 48 spindles. The units receive roving from the ATDA roving centre and sell their yarn to the centre. Unit that process warp beam use yarn bought from the pedal spinners. The processed beam is distributed among cottage weavers, who use the ATDA-developed pedal-loom.

The RFC is a decentralized unit of the type promoted by KVIC, India, under the Loke Vastra scheme, which comprises spinning and weaving with pedal-looms. There is little difference between RFC and ATDA technology; both use rebuilt preparatory machinery. One such RFC unit in South India has a capacity of 1000 spindles and 10 pedal looms. The RFC unit, unlike the ATDA roving and service centre, spins yarn and processes beam for pedal-loom weavers in the same premises. The other important difference is that the RFC does not process raw cotton in the same premises -- opening and cleaning operations take place centrally and processed laps are supplied to four or five rural fabric centres.

The RFC Power spinning is not a realistic alternative for the cottage weavers in Bangladesh as access to power is difficult. Instead, replacing bamboo Charka spinning (at present used by cottage spinners) by pedal spinning would be more practical. In this study, the RFC composite technology has been modified to include power-looms, as these are gaining importance in Bangladesh. Alternatives comprising RFC power spinning combining pedal- and power-looms, RFC power spinning and handloom and ATDA (roving), pedal spinning and handloom are shown in Fig. 2.

RFC and ATDA combined technologies are not in operation in Bangladesh. Therefore, the introduction of these technologies has to be organized by either the public or private sector. Studies on small-scale cotton spinning (Mia, 1983, pp. 26-27; 1985, pp. vii-viii) advocated that these initiatives come from external donor agencies such as ATDA and the Intermediate Technology Industrial Service (ITIS). The donor agencies suggest that transfer of ATDA roving-centre and pedal spinning technology to Bangladesh would increase the present daily income of hand-spinners and handloom weavers from BDT 10 to BDT 20.

The spinning technology used in Khadi-yarn making has undergone a series of developments. The single-spindle wooden charka was replaced in the early 1950s by a four-spindle one known as the Ambar charka. Sri Balasundaram, an Indian mechanical engineer, made further improvements and introduced the six-spindle charka. This charka incorporated many features of the standard mill machine known as the new-model charka. The KVIC has initiated development of preparatory spinning machinery suited for small-scale production. These machines are known as Purbo Pesai (for opening and cleaning of cotton) and Uttar Pesai (carding and drawing) and are driven by power, while roving is made by a hand-operated charka that is similar to the new-model spinning charka but has four spindles.

Khadi production is mainly organized in two ways: one through a Khadi institutions, which provides inputs, marketing and development of the product, maintenance and training. In this system, the roving and spinning charkas are distributed to the cottage level and the KVIC supplies input (sliver and roving) to the cottage rover and spinner. They in turn hand over their finished product to the institution for payment. The other method of production organized through a factory, is known as new-model charka units. This method uses all preparatory machinery and supplies sliver to roving charkas and subsequently roving to new-model charkas in the same premises. Operatives work daily and get paid on the weight of output. Handloom weavers receive their yarn from the Khadi institution and return grey woven cloth, being paid on the length of fabric woven. Instead of pedal-looms they use pit or semi-automatic looms. The KVIC technology alternative combining KVIC spinning and handloom is shown in Fig. 2.

The KVIC spinning technology is not widely used in Bangladesh, except in one institution where hand spinning is organized under factory conditions. In this institution, KVIC-developed preparatory spinning and a few new-model charkas are in use experimentally. But in general, hand spinning technology is dominated by primitive opening and cleaning operations known as Dhunai, followed by bamboo or wooden charka spinning.

Source of data

Technical and economic data for the present study were collected as explained in the previous chapter. As the study is country specific, the data collected represent the characteristics of the textile industry in Bangladesh for both modern and the traditional sectors. Visits were made to several textile mills using alternative sources of machinery of different vintages. For handloom, 214 interviews were conducted, keeping in view the locations involved. For intermediate technology, information came entirely from visits undertaken to different decentralized spinning and weaving units in India. However, for power-looms, information was collected from Bangladesh. Information on KVIC technology was gathered partly from one spinning institution in Bangladesh. Further details were obtained from visits to Khadi institutions in various part of India.

Machinery prices for modern alternatives from United Kingdom, Japan, Romania and India have been collected from the manufacturers' sales agents in Bangladesh. A complete range of machinery, from opening and cleaning to weaving, is not available from a single manufacturer. To overcome this constraint, subprocess machinery was substituted from the same country source but from different manufacturers; where such machinery was not available, different sources of machinery or synthetic machinery with adjusted machinery prices have been used.

Estimate of the costs of buildings and infrastructure have been made from the information provided by the Bangladesh Textile Mills Corporation (BTMC) and the private mills. The estimates for building cost vary with the location of the plant. This variation could be due to different transport costs, local availability of materials and workers and accessibility to power connections and to the location itself. Such variations have been accommodated in the calculated estimates for building costs.

The data on financial and technical characteristics have been collected for alternative sources of machinery. A total of 17 textile mills have been selected, of which 5 are integrated. The samples have been based on locational variability, unit size and machinery vintages. These data cover a period of 5 five years, and mills commissioned after 1972 have been given priority when selecting samples.

The private weaving sector mainly provides information on power-looms. Power-looms are locally manufactured and their prices and installation costs have been obtained from the local manufacturer. Information on machine productivity, manning and technical and economic characteristics has been obtained from five surveyed private mills producing sheets, towels, shirting etc. from cotton and synthetic yarn.

Intermediate technology machinery prices have been collected from several sources. The price of pedal spinning machines has been obtained from the ATDA. Those of preparatory spinning and spinning frames with 48 spindles were collected from South India. The ATDA preparatory machines for the service centre currently in use are rebuilt. The price of rebuilt machinery was, therefore, collected from South India. The prices of preparatory weaving machinery (hand-to-cone winding, pirn winding and sectional warping) have been collected from South India and Bombay. All these prices have been used to cost a complete production process of intermediate technology.

The buildings used in intermediate technology differ from those of the modern sector, and estimates of building costs have been based on information supplied by the Engineering University, Dhaka, Bangladesh and the planning and development directorate of BTMC.

Technical and economic data have been collected from the three decentralized units in India, all information on ATDA service centre technology was collected from the ATDA head office at Lucknow and the pilot project at Kushmi Kalan (Uttar Pradesh), India. The author also had several meetings with the project director on the development of the proposed cottage-spinning technology. Some of the workshops that manufacture these machines were also visited. Information on the productivity of pedal charka and beam was established from the survey in villages around Kushmi Kalan. Information on decentralized, RFC spinning and weaving was collected from the KVIC unit in Coimbatore, South India, which also includes a central opening and cleaning unit that supplies cotton laps to RFC units.

A number of sources are available in India for new-model charka equipment. Information on machinery prices was obtained from the KVIC head office in Bombay and from a manufacturer in Ahmedabad. Data on productivity and maintenance and other technical characteristics have been collected from several sources. Information on the production system organized by the distribution of Ambar roving and spinning charka at the cottage level come from Ahmedabad with the help of a short questionnaire administered by the author to a sample of 20 rovers and spinners. Information on new-model charka (under factory-shed conditions) was collected from two units, one in Coimbatore, South India, the other in West Bengal. The technical and economic data have been compiled with the help of a questionnaire designed for these units.

Technical and economic data on the handloom sector are very scarce. Although some information is available on production and cost characteristics of handlooms, it is subject to large variations. The handloom census of 1978 showed, based on 2 months yarn consumption, suggests per-loom production about 12.30 m^2/d, whereas the consumption figure given by the Bangladesh Bureau of Statistics suggests that it should be about 10.24 m^2/d. Moreover, these production estimates are based on different product types. Information on preparatory weaving, for example, equipment price, production, manning and operating costs is not available from any source. For a proper evaluation of this sector, therefore, detailed information on technical and financial characteristics is required. As handlooms are found in different pockets of the country and their numbers, looms and product types vary, information on this sector should accommodate such variations.

A questionnaire was used to collect information from cottage handloom weavers. A sample of 214 cottage weavers was selected from four areas in Bangladesh.

Technical and economic parameters

It is necessary to establish the parameters for technical alternatives if these are to be evaluated. These parameters include the characteristics of product and equipment, productivity levels, wage rates etc.

Modern technology is designed to have a lower wastage level than intermediate and traditional technologies. Consequently, to achieve a comparable level of output, it is likely that the intermediate and traditional technologies need to process more materials than do modern methods. This increases processing time and thus increases their operating cost. Table 9 shows the subprocess wastage level for modern, intermediate and handloom technologies. No difference in subprocess wastage level is found between modern and intermediate power spinning. This shows that the materials are processed inefficiently in the modern sector of Bangladesh. The subprocess wastage levels of ATDA (pedal) and the KVIC (khadi-ambar) technologies are identical up to spinning but they have higher levels of wastage in roving and spinning than modern and intermediate spinning. For weaving, the wastage level between modern and intermediate (RFC) technologies (pedal- and power-looms) varies only in the pirn-winding process. Variation of wastage levels is very significant for handloom weaving compared to all weaving technologies. The service centre has identical wastage levels to that of RFC preparatory weaving.

Different technologies can be used for the same product, but the result may differ in quality and characteristics. This problem may limit an unqualified comparison between alternative technologies. The most important aspect of the quality of yarn is its regularity and strength, while for fabrics it is its compactness, tear strength etc. It is generally the case that the quality of product suffers when the textile process moves from modern to intermediate and to traditional technologies. However, it is possible to overcome this problem partially if the product is of medium to low quality -- i.e. the fineness of the yarn is below 40s English count. The number of subprocesses increases beyond this count when quality control becomes relatively more important.

The present study focuses on yarn of 32s English count, first, because this particular count of yarn is the largest share of yarn at present produced by the local mills (about 35% in 1988); second, because it is widely used by the handloom sector. Finally, this product can be produced by all the twelve alternative technologies without significantly affecting the product quality.

The fabric would be grey, also using yarn of 32s count. The construction of the fabric is important, because it determines the quality, unit cost and also the market it is producing for. Although a wide variety of construction of fabric is technically feasible, for present purposes we will consider fabric constructed as follows:

Product specification

32s cotton yarn

Warp: 21.26 ends/cm
Weft: 21.26 picks/cm

Modern sector weaving

Unfinished cloth width: 142.24 cm

Selvedge: 0.098 cm on both ends
with 32/2s cotton yarn

Total ends: 21.26 X 142.24 + 27 = 3051
Total picks: 21.26 X 100 = 2126/m^2

Intermediate and traditional weaving

Unfinished cloth width: 102 cm

Selvedge : 0.098 cm on both ends
with 32/2s cotton yarn

Total ends: 21.26 X 101.6 + 27 = 2187
Total picks: 21.26 X 100 = 2126/m^2

Annual Production: 31 million m^2/yr.

This fabric is of medium quality and is widely in use in Bangladesh. The modern composite mills and the handlooms produce about 70% and 75% (1988) of their product in medium quality.

The scale of output is estimated on the assumption that maximum economy of scale would be realized from modern machinery. In the modern production process, the important machines (spinning frame and loom) are each of small capacity. It is technically feasible to combine one spinning frame with 20 looms without any adverse effect on economies of scale, but the problem arises when other subprocess machinery (opening and cleaning, warping and sizing) is included in a single production process. Pickett and Robson (1981, pp. 4-5) state that, because of the high capacity of opening and cleaning machinery, the optimum economy of scale would be realized at an annual output level of 21 738 600 m^2. Even at this output level the warping and sizing machinery would use only 50% of capacity. The output level, however, varies with the type of product.

The U.K. spinning output is used as the standard basis for comparison. Spinning frames from the U.K., Japan, India and Romania all have a rated speed of 16 000 rpm, have ring diameters of 44.45 mm and have a lift of 22.86 cm. The Japanese and Indian machines are recommended to operate at 13 000 rpm and have a production per spindle per shift of 127 g. The U.K. machine is recommended at 13 200 rpm and has a production per spindle of 129 g per shift. The Romanian machine is recommended at 12 900 rpm and has a production figure of 126 g per spindle per shift.

The production per spindle can be calculated from the product type (the yarn count), the twist inserted per centimetre and the spindle speed. If the number of spindles is known the total yarn output can be estimated.

To calculate the final output two facts are required: the numbers of spindles used and the subprocess wastage level. The number of spindles can be estimated from the production capacity of the opening and cleaning subprocess -- by making allowances for wastage in each subsequent subprocess, the amount of material to be processed at the spinning stage can be found. From the spindle rpm, the type of product and the twist/cm, the number of spindles can be calculated. This shows that the number of spindles could be up to 25 000 -- the capacity of all the textile mills commissioned in Bangladesh since 1977, except for one of 12 480 spindles.

The exact number of spindles may not be matched by alternative sources of technologies as the number of spindles per frame varies for different machinery sources. This spindle capacity to 25 000 could produce 2 533 000 kg/yr of 32s count cotton. If this intermediate yarn is being directly processed in the weaving section the grey cloth output would be 31 million m^2/yr.

It has been assumed that for modern technologies construction and installation would be completed within the 33rd month. At the last 3 months of the 3rd year the trial production period (TP) will commence. During this period, the operational efficiency would be between 45% and 50%, or 12% of the full production capacity. In the 4th year, operational efficiency would be 70% to 75%, or 84% of full production capacity. In the 5th year, the production level (PL) would be 100% of the production capacity 2.53 million kg of yarn of 31 million m^2 of grey cloth. Machinery of intermediate and traditional technology requires less time for installation than that of modern technology. Field surveys of Indian intermediate technologies show that these alternatives have the same production build-up as for the modern technology.

The number of working days a year observed in mills in Bangladesh is 300 to 345. In the present study it has been taken as 300 days in a year. Shift working is essential to reduce the impact of rising investment cost. This study assumes three-shift working in modern spinning and composite units, intermediate spinning and power-loom weaving, intermediate prespinning and spinning and service centres (preparatory weaving). For KVIC ambar charka one shift is assumed. For pedal spinning and handloom weaving, average daily production is used.

Although, ATDA prespinning (roving) and RFC power spinning run either on three or one shifts, here they have been considered to operate on a three-shift basis. There is no technical limitation here; it would be an organization matter to operate on three shifts.

The working life of the project is assumed to be 20 years. Adding to this the 33 months construction and installation period (CP) we have a total project life of 23 years. For intermediate technology (ATDA and RFC) and KVIC, total time for construction and installation of machinery would be 21 and 9 months respectively, trial production starting in the 22nd and the 10th month. In the case of handloom, it is assumed that these looms are newly installed in the cottage weavers' homes. Thus, construction times and project lives are:

Project lifespan (years)

	1	2	3	4	5 to 23
Modern	CP	CP	CP/TP (12%)	PL (84%)	PL (100%)
ATDA & RFC	-	CP	CP/TP (12%)	PL (84%)	PL (100%)
KVIC	-	-	CP/TP (12%)	PL (84%)	PL (100%)
Traditional	-	-	TP (12%)	PL (84%)	PL (100%)

These assumptions are based on information on the modern sector obtained from the BTMC and private sector, the intermediate and KVIC technologies from the Indian survey and traditional technologies from the handloom survey.

Any meaningful comparison of the technologies depends on the assumption that the life of machinery is the same for alternative technologies. For modern machinery, a 20-year working life is acceptable (in Bangladesh, the technology vintage of 1936 is still in use). As regards intermediate technology a lifespan of 20-years invites some doubt, as some of the machinery is rebuilt from 1930-1950 vintage. Evidence that favours the assumption of identical machinery life comes from a factory visited in Coimbatore, India, which had been using its machinery 11 years without any major maintenance. The KVIC ambar charka machinery was observed to have similar life pattern. However, some machinery cost adjustment for intermediate and KVIC technologies would help to strengthen the equal life assumption. The obsolescence of textile machinery results from changes in economic suitability and technological development (higher speed and machine capacity) rather than any mechanical failure. In the case of traditional technology (handloom), an equal machinery life assumption would not be valid. The pit-loom could have a life of 6 to 8 years, the CR-loom 12 to 15 years, with partial overhauling. The machinery life for alternative technologies has therefore been assumed to be 20 years for modern technology and for intermediate technology (ATDA, RFC and KVIC) with one major modernization required during the project life. We assume replacement of pit-loom machinery four times during the project and replacement of the CR-loom twice during the project.

Investment costs are adjusted according to these machinery lives. However, the assumed lifespan could be shortened because of high utilization level and poor maintenance.

The textile industry in Bangladesh is almost totally dependent on imported machinery, spares and raw materials. Therefore, the proximity of plant to seaport has an important bearing on investment cost as well as a long-term effect on the operating cost. When comparing alternative technologies with different input and labour content producing for different markets, location becomes important. To overcome this problem, it could be assumed that both modern and intermediate production units together with handloom weaving are located near a seaport, which will equalize transportation and distribution costs.

Taking the present structure of the textile industry into consideration, it has been assumed that the modern sector mills would be located near Dhaka city, with intermediate and the KVIC technologies in Dhaka district. Dhaka being at the centre of the country, its transportation and other costs represent the cost for a wider area of the country. The plants using intermediate and KVIC technologies would be close to handloom-concentrated areas. Their access and infrastructure would not be as developed as had they been near Dhaka city; they would, therefore, require some adjustment in transportation cost.

Maximum energy is consumed in the spinning process. Here consumption varies with the spindle speed. Power input could be categorized into two main areas: preparatory spinning and weaving; and spinning, cone and pirn winding. The consumption for the former subprocesses usually occurs at a constant rate, whereas for the latter it increases with the build-up of the yarn packages, i.e. as more yarn is wound in the yarn cop, power consumption increases. Calculation of actual power consumption should take note of motor efficiency, variations in yarn count and spindle speed.

Power consumption for the preparatory subprocesses is assumed to be 80% of installed capacity, while for ring-spinning it is adjusted for product type (32s count) and spindle speed according to the chart in Catling and Barr (1965, pp. 161-194).

<u>**Productivity assumptions**</u>

Two mills of identical size using machinery of the same vintage and with same maintenance standard can differ widely in productivity. Pickett and Robson's (1977a, pp. 879-882) cross-sectional data suggest that this variation is significant in the developing countries. The variation in productivity can be attributed to technical and organizational factors.

Technical factors refer to the machine speed and the operating efficiency of the spindles and looms. The spindle speed, for example, depends primarily on yarn count, twist factor and fibre strength, while spindle efficiency is the ratio of the rated capacity (C_r) to actual capacity (C_a). For spindle or loom capacity, the manufacturer recommends an operational capacity for specific country conditions, which would be defined as recommended or expected capacity (C_m), and this differs from the rated capacity. However, the actual capacity (C_a) is nearly always lower than the manufacturer's recommended capacity.

Given optimal management practices, it would be possible to attain $(C_m) = (C_a)$. Productivity deficiencies embody avoidable and unavoidable stoppages. In theory, avoidable stoppages can be completely eliminated, as they could be due to yarn breakage, developing-country conditions etc. Unavoidable stoppages such as power failure cannot be eliminated but can be minimized. Power failure is the major cause of low productivity in Bangladesh. During 1980-88 between 4% and 14% of the total production time was lost owing to power failure. Better job training and working conditions also help to increase productive efficiency.

In textiles, several measurements of productivity are in use. One method compares a mill with a standard mill having optimal organization and labour use. The standard mill is established with the help of a productivity centre. Another method is the Van den Abeele System. Here a productivity index (PI) is worked out by comparing the actual man-hours required to produce 100 kg of yarn (actual HOK) with the man-hours expected (UNIDO, 1967, pp. 111-116). A third method used by Ahmedabad Textile Industries Research Association (ATIRA), India (ATIRA, 1978, pp. 1-5), calculates the productivity index as:

$$PI = \frac{MPI}{LER} \times 100$$

$$\text{where MPI} = \frac{\text{Mill production per machine shift}}{\text{Standard mill production per machine shift}}$$

$$\text{and LER} = \frac{\text{Mill operatives per shift}}{\text{Standard mill operatives per shift}}$$

Among these methods, the basic difference arises from whether productivity is measured on an inter- or intra-mill level. The BTMC has standard manning levels for all mills; these do not vary according to type of machine but may vary according to their numbers. For the purpose of this study the ATIRA method could be used, as it suits Bangladesh textile production systems, this, however, required some assumptions. If the mill operatives required per shift are the same as that of the standard mill operatives, then LER equals 1. Therefore, the productivity index (PI) equals the MPI X 100.

The productivity index would then be a function of the machine productivity index. As the manning level is almost identical across modern alternatives, labour productivity depends on the performance of specific technology sources. If it is assumed that the standard machine production is the manufacturer's recommended or the expected production under country conditions then PI could be expressed as:

$$PI = \frac{\text{Actual capacity of machine per shift}}{\text{Expected or standard machine capacity per shift}} \times 100 \qquad \text{(i)}$$

It can also be defined as:

$$\text{Recommended efficiency} = \frac{\text{Expected or standard machine capacity per shift } (C_m)}{\text{Rated machine capacity per shift } (C_r)} \qquad \text{(ii)}$$

$$\text{Actual efficiency} = \frac{\text{Actual machine production per shift } (C_a)}{\text{Rated machine capacity per shift } (C_r)} \qquad \text{(iii)}$$

From these equations, a fourth relationship can be derived:

$$\text{Actual efficiency } (A_{eff}) = \frac{C_a}{C_m} \times \text{recommended efficiency } (R_{eff}) \qquad \text{(iv)}$$

The figures on the right side of these equations may be multiplied by 100 to provide percentages.

If the actual, expected and the rated machine capacities are known for old and new vintages, then by calculating PI for the older vintages, the actual productivity of the new machinery can be estimated. It is to be noted that under standard mill conditions, the values of PI, R_{eff} and A_{eff} = 1 or 100. Ideally, PI and the efficiencies can be calculated for all the subprocesses and then combined to give an overall index. However, it has been assumed that the productivity level of spinning and weaving would be adequate as a measure of overall productivity.

Table 10 provides detailed machinery and productivity information from 17 surveyed textile mills in Bangladesh -- 5 from the U.K., 7 from Japan, 4 from India and 1 from Romania. Indian and Romanian machinery were first installed in Bangladesh after 1975, and at the time of the survey there were only four Indian and one Romanian mills in operation although a number were under installation.

The table shows that U.K. spinning machinery (1968-71) had a recommended speed between 11 000 and 11 500 rpm, with an expected per spindle production from 96.67 g to 100.92 g per shift. However, the actual spindle speed attained is between 8 200 and 9 274 rpm with spindle production between 80.23 g and 93.55 g per shift. The calculated productivity index varied between 81.5 and 92.7, while the average index for the five samples is 87.02. Similarly, the average PIs of the Japanese, Indian and Romanian spinning machinery have been calculated and are 90.3, 85.55 and 87.36 respectively. It shows that the Japanese spinning machinery has achieved the highest PI, while the productivity levels of Romanian and U.K. machinery are almost the same and are higher than the Indian.

Table 11 shows that the rated spindle speed of spinning alternatives (1981) varies between 15 500 and 16 000 rpm while the recommended spindle speed varies between 12 900 and 13 200 rpm. At the recommended spindle speed, expected production varies between 113.68 g and 116.09 g per shift. The estimated actual level of spindle productivity of U.K., Japanese, Indian and Romanian technologies are 101.0 g, 103.33 g, 97.92 g and 99.31 g per shift respectively. The actual spindle speed that could be attained, therefore, lies between 10 010 and 10 565 rpm, while actual efficiencies vary between 78.2% to 81.3%.

<u>Weaving technology</u>

The absence of data on weaving machinery from sources other than Japan limits the determination of productivity levels of machinery and equipment from the U.K., India and Romania. It is assumed that productivity levels of weaving machinery from these sources are more or less the same as that of the Japanese machinery, considering that the productivity level for weaving is less variable than for spinning across alternatives.

Table 12 shows that the expected pick per minute for machinery of 1962, 1963 and 1964 vintages varies between 140 and 145, while production of cloth per shift varies between 31.62 m^2 and 32.74 m^2. The variation between the expected and actual productivity levels is small, as all the looms are of almost the same vintage. The actual loom productivity is observed to vary between 24.65 m^2 and 26.20 m^2 per shift. The productivity index (PI) varies between 83.65 and 92.42 across five composite mills.

Table 13 shows the expected and the estimated actual productivity levels for alternative sources of weaving technologies. The expected loom productivity of U.K., Japanese, Indian and Romanian technologies (which are based on manufacturers' recommendations), are 34.56 m^2, 30.50 m^2, 32.53 m^2 and 32.53 m^2 per shift respectively. The estimated actual productivity levels of these technologies are 30.19 m^2, 26.65 m^2, 28.42 m^2 and 28.42 m^2 per shift per loom respectively.

As the actual productivity is below the expected level, the annual output of 31 million m^2 cannot be met in 300 working days. The number of working days will, therefore, have to be more. However, if the actual productivity level is very low then the comparative scale of output may not be attained in the same year. In such a case, additional machinery will have to be installed, but the investment cost will increase subsequently. Increasing the number of working days to increase output will not raise the investment cost but will instead involve additional operating cost due to increase use of labour, power, maintenance and overhead.

As the productivity level for pedal-, power-, pit- and CR-looms, ATDA pedal and KVIC hand spinning have been based on actual production, no adjustment in the number of working days is required for these technologies. An adjustment is required for modern spinning and weaving and some intermediate technologies. For intermediate technology, the expected productivity level of RFC spinning has been taken from observations made in India. It has been assumed that the actual productivity level in Bangladesh will be lower than in India. The Indian productivity level has been modified in accordance with the spindle production of machinery from 1927 and 1936 vintage at present operating in Bangladesh. The technical features of this machinery are comparable with RFC spinning. The number of working days for RFC composite units has been adjusted for spinning only, as the productivity level for power-looms was based on the level observed in the private textile sector of Bangladesh. For pedal-looms, the Indian productivity level was used, as it was found to be not significantly different from the semi-auto or CR-looms.

To produce 31 million m^2 of grey cloth at the expected productivity level, the composite spinning unit requires 300 working days, while for supplying yarn to the service centre and the handloom weavers it would require 308 and 310 days respectively. At actual productivity level the number of working days increases for a composite spinning unit from 300 days to 340, 332, 351 and 344 days for U.K., Japanese, Indian and Romanian technologies respectively. Similarly, the working days increased for service centre and handlooms (pit and CR) weaving from 308 days and 310 days to 349, 341, 359 and 352 days; and 351, 343, 362 and 355 days respectively for U.K., Japanese, Indian and Romanian technologies. An intermediate spinning unit supplying yarn to the handloom weavers requires an increase in working days from the 300 days entailed by an RFC composite unit to 309 days. In actual production, the number of working days required by an RFC composite spinning unit increases from 300 to 340 days, while for supplying yarn to the handloom weavers it requires an increase from 309 to 350 working days. As it has been assumed that the actual productivity levels of all weaving alternatives are based on Japanese technology, therefore, the required number of working days for all alternatives increases in the same proportion from 300 to 343 days.

Wages and salaries

In Bangladesh, a large proportion of manufacturing takes place in the public sector. The wage and salary structure is uniform in this sector and is known as the national pay scale (NPS). The NPS is designed to accommodate the skills of labour and administrative personnel. Therefore, for investment in the modern textile sector, this wage structure can be applied. But, as intermediate and KVIC technologies are not in operation in Bangladesh, considerable difficulty arises in determining appropriate wage levels -- Indian wage rates for this sector are even higher than those in the modern sector in Bangladesh. The wage level may vary according to whether the investment is undertaken by the government or by private entrepreneurs. Other wage areas to be considered are for handloom and pedal spinning; for these, the wage levels found in the handloom survey and as observed in a hand spinning unit in Bangladesh can be used.

I assume that modern-sector investment would be in the public sector (i.e. the BTMC); therefore, the wage and salary structures of the textile industry are used. They are broadly similar to the NPS. The lowest scale is BDT 225-315 for non-administrative personnel. The highest, grade eight, is BDT 400 rising to BDT 555. In addition there are allowances -- 35% of the basic salary for rent and BDT 50 as medical benefit -- which are uniform for all grades. In the textile industry, unskilled workers in grades one and two average a total of BDT 484 per month. Other unskilled workers in grade three average a total of BDT 575 monthly, semiskilled workers in grades four and five average BDT 630 monthly, skilled workers in grade six average BDT 706 monthly. Supervisors average BDT 841 monthly.

Those employed in the modern sector can be classified into the above skill composition. Once such a skill differentiation is established, it is easy to calculate overall wage costs.

The salary structure of the public-sector enterprises is used to establish the salaries of administrative and the managerial staff. There are as many as 20 scales, of which 9 are used by the textile sector. Basic textile-pay scales are identical across the country; however, allowances such as house rent vary according to locations. In cities where accommodation for administrative staff is not provided, there is provision for a fixed house rent. If accommodation is provided, the cost of it is deducted from basic salary at the rate of 5% to 7.5%. The lowest of those scales begins at BDT 225 monthly, with annual increments of BDT 6 to BDT 315. The scale averages BDT 285 with allowances of BDT 230 to a total of BDT 515. The highest scale starts at BDT 2300 with increments of BDT 100 to BDT 2750; the average in the scale with net allowances is BDT 2695.

At the higher end of these scales we assume that housing is provided within the mill compound. The cost of this has been deducted from basic salaries at the rate of 5% to 7.5%. At the lower end, 30% is added to the basic pay for rent allowance. Personnel also get allowances such as a gratuity at 6% of basic pay and the medical allowance of BDT 50.

Intermediate spinning and weaving are not widespread in Bangladesh. Accordingly, it has been assumed that such production, if undertaken, would be organized under the public sector, as in India. This would resolve the problem of wage determination for this technology to a great extent. The BTMC wage and salary structure could be applied for intermediate technology once the skill composition can be established. The requirements of the intermediate alternatives would be in a lower spectrum of the skill composition than that of the modern sector. In modern spinning, for example, a spinner operates between 432 and 480 spindles, whereas a spinner in intermediate spinning under factory-shed production (RFC spinning) operates a maximum of 48 spindles, including doffing.

It would be convenient to use the NPS or the BTMC wage scales for the service centre, ATDA prespinning, KVIC prespinning, RFC spinning and preweaving and RFC composite units with power-looms. All these subprocess use power-driven machinery and it is assumed here that all their operatives are employed on a permanent basis. Furthermore, shift working is possible and has been considered for all operations except the KVIC prespinning. However, problems arise for pedal charka, ambar roving and spinning and pedal-loom. These operations involve direct human power and are usually run on a one-shift basis. Operatives are paid on the amount of product they deliver at the end of the day; their daily or weekly wages therefore, vary with and depend on their skills.

Wage rates for pedal and ambar rovers and spinners have been estimated from the only production centre in operation in Bangladesh. The daily wage rate is related to the productivity of the operatives. It has been found that the average wage paid for 32s cotton count is BDT 4.50/kg of yarn. Accordingly, the average earning of an ambar spinner would be BDT 8.14/d, while a pedal spinner could earn BDT 19.35/d. The ambar rover, on the other hand, earns BDT 3/kg -- an average daily wage of BDT 8.66. However, ambar rovers and spinners also get food rations at a very subsidized rate, which, it can be assumed, would bring their wages to BDT 10/d. Based on this, annual wages of ambar rovers and spinners and pedal spinners for 300 working days would be BDT 3000 and BDT 5805 respectively. It appears that a pedal spinner earns the wages of an unskilled worker in the modern sector.

The wage structure thus established can be used to calculate the total wage costs for intermediate alternatives. The salaries of the administrative staff for this sector could be taken from the scales of the modern sector -- from the lower end of the scale, as production units are relatively small.

Wage rates for traditional technologies have been estimated from the survey conducted on 214 cottage weavers. Here, wage rates closely relate to productivity; therefore, it is essential to establish average daily production.

Wage rates can be divided into two main groups -- preparatory weaving and weaving. Although there may be variations in processing costs, depending on location, an average could be found to calculate the daily wage rate of preparatory weaving operations. Wage rates of the weavers vary with product type -- cloth construction and yarn count -- and on the design used on the product. They also vary with the location -- for example weavers near handloom trade centres are usually paid higher wages than those in remote areas. It is important to convert the product type found in the survey to the product quality used in this study (i.e. 32s cotton count) before estimating the wage rate. It has also been observed that the wage payments can be in different forms. For example, weavers are sometimes provided with meals beside wages. However, wages often are paid piecemeal; for instance, for a sari, which is usually about 5 m long, a fixed amount is paid. The handloom survey estimates a weighted average daily production that also takes into account locational variations. Daily wages received by preparatory weaving operatives are BDT 4.20 for a bobbin winder, BDT 16.50 for a prewarper, BDT 24.75 for a drum-man or warper, BDT 4.13 for a pirn winder and BDT 10.00 for drawer engaged in warp drawing in operation. A pit-loom weaver is estimated to earn BDT 13.06 and a semi-automatic-loom weaver BDT 16.98.

Thus bobbin and pirn winders receive relatively low wages -- the operatives being either old women or children of 8 to 12 years, and sometimes housewives; their productivity is low because of the frequent breaks taken by them for household work. The wages of drum men (warpers) are very close to those of semiskilled workers in the modern sector, while the wages of drawing-in operatives and ambar spinners are about the same. The annual wages of prewarpers and the CR-loom weavers have marginal differences (BDT 4950 and BDT 5094 respectively). These wages fall about 14.8% and 12.3% below those of the unskilled worker in the modern sector. The wage of the CR-loom weaver is 29% higher than that of the pit-loom weaver because the former has higher productivity. The wage structure of the traditional sector shows that except for the drum-men, incomes for all operatives fall below the level of modern intermediate sectors.

Chapter Five

Selection of machinery

In this chapter, technologies are specified according to production capacity, floor space, power consumption and manning requirements. The assessment of machinery required also takes into account the quantity of product to be processed at each stage. A system to balance the number of factory units for alternative technologies is essential. For example, output that could be produced in a single factory with modern technology may require a number of units by intermediate, Khadi and Village Industries Commission (KVIC) and traditional technologies. The input-output balance of the units between modern, intermediate and traditional technologies is determined by fixing the annual output of all 12 alternatives at 31 million m^2 of cloth.

When the textile production is organized under a factory shed, it is important for efficiency that each subprocess produce a balanced output for the next process. Units of opening and cleaning, sizing and warping machinery have high capacities, whereas other subprocess machinery is fairly divisible. This suggests that a unit size with 25 000 spindles would exploit technical economies of scale, although beyond this capacity there may be some management and administrative economy. The selection of machines would, therefore, take into consideration the technical economy of scale, product type, subprocess wastage and maintenance practices. However some surplus capacity at each stage may be desirable to accommodate any production loss due to machine breakdown or other failures. The selection of machinery would depend on whether the output is intermediate or final. If a unit is producing intermediate yarn to supply the handloom sector, additional subprocesses (reeling, bundling and bailing press) beyond the spinning section would be required to market the intermediate output. The composite unit that produces grey fabric does not need these subprocesses. However, the subprocesses of traditional technology may not be the same as those of the modern sector. They may entail little equipment, but employ labour for certain tasks such as warping and reeling. As machinery in the modern sector may come from different sources it may happen that a single manufacturer of a complete process is not available. In such circumstances, the subprocess machine would best be supplied by another manufacturer from the same country.

Modern-sector technology

The technical literature on the modern sector contains information on speed, power and floor-space requirements and the recommended efficiency of machine. The spinning and weaving plan from the manufacturer specifies levels of manning and the efficiency to be expected in a particular country condition. This information was collected from machine manufacturers in the U.K., Japan, Romania and India. Information is more complete for spinning than for weaving.

The selection of spinning machinery is based on the expected capacity and efficiency as recommended by the manufacturer. The balancing of each subprocess output is based on daily production. The number of spindles for the balancing of opening and cleaning subprocess output has been estimated to be about 25 000. As information on spindle speed, expected efficiency and production is available, total production in the spinning sector can be calculated. From this output and the quality of yarn, the net output required at each preceding subprocess can also be calculated taking the wastage level into account. The output at each subprocess level also takes into account the loss due to maintenance work and probable break-down, plus provision for buffer output for maintaining a balance in the production process. The number of machines required at each subprocess level can be calculated, as the productive capacity of each machine is known. These have been calculated for machines from U.K., Japan, Romania and India and given in Table 14. The table shows that the number of machines for alternative technologies varies at the subprocess levels. For example, for carding, the U.K. technology requires only 18 machines, whereas for Japan and India, it is 20 and for Romania 22 machines. The table also gives installed power requirement for each machinery at the subprocess levels, from which the total installed power is calculated.

Indian machinery requires a factory with a minimum floor space of 8010 m^2, which increases progressively for Japan, Romania and U.K. to 8195 m^2, 8226 m^2 and 8338 m^2 respectively. The difference in floor space requirements for alternative machinery sources is found to be small -- about 4%. Requirements for warehouse, workshop and offices (1880 m^2) and residential accommodations (1907 m^2) are taken to be the same across technologies.

Skill requirements across the alternatives are not significantly different except for semiskilled workers. Table 15 shows that Romanian spinning provides the highest direct production and maintenance employment of 811 (most of these being employed at the spinning section), followed by Indian, Japanese and U.K. technologies of 773, 751 and 737 respectively. Requirements for workshop operatives and administrative personnel are taken to be identical for all technology sources. This poses no problem, as the size of the spinning units of all the machinery sources are almost the same. Numbers of workshop operatives and administrative and other personnel are 30 and 205 respectively for each alternative. This brings the total employment level for U.K., Japanese, Indian and Romanian spinning alternatives to 972, 986, 1008 and 1046 respectively.

The absorbed power consumption is not necessarily the total installed power. An absorption factor is required for the count of yarn chosen. The absorption factor for 32s yarn count is estimated to be 0.8. U.K. spinning technology requires the highest annual installed and absorbed power (10.06 million kWh) followed by Indian (9.61 million kWh), Romanian (9.39 million kWh) and Japanese (8.85 million kWh). The total consumption includes air-conditioning, lighting, power pump and miscellaneous consumption of 2.16 million kWh, which is assumed to be identical across the technologies. Lighting is estimated to be 0.0067 kWh/m^2. Thus the U.K. technology consumes about 4.7%, 7.1% and 13.67% more power than the Indian, Romanian and Japanese technologies respectively.

The selection of machinery for the composite units follows the same procedure as for spinning, being based on recommended efficiency, expected capacity and subprocess level wastage. Table 14 shows the number of weaving machines required for U.K., Japanese, Indian and Romanian technologies along with their installed power requirements.

The table shows that the alternative technologies require different numbers of machines at the subprocess level. For example, U.K. and Japan require 725 and 825 looms respectively to produce 31 million m^2 of cloth. The number of looms required by the Indian and Romanian technologies is identical at 775. The Japanese loom has a lower production than the Indian. This does not indicate the superiority of the Indian looms; rather the local supplier for the Japanese looms quotes lower production capacity.

A single source of machinery may not be available for a complete production process. It is possible to construct a complete textile process for Japanese and Indian technologies, from the same country source if not from the same manufacturer. The problem arises with the U.K. and Romanian technologies. For U.K. weaving, except for the automatic looms, the cone-winding machinery is supplied by France (as in spinning), while warping, sizing and pirn winding machinery comes from North America. No information could be found on Romanian preparatory weaving machinery or looms from the local supplier or the country source, except for cone-winding machines; other preparatory and weaving machinery comes from Indian sources because of their similarities in technical features and price. A comparative price coefficient is estimated to adjust Romanian preparatory and weaving machinery prices.

Total space requirement for the composite spinning and weaving unit using Japanese technology is the highest at 20 175 m^2. For a composite unit using Indian, U.K. and Romanian technologies, space requirements are 19

762 m^2, 19 877 m^2 and 19 977 m^2 respectively. The variation of space requirements across technologies is negligible.

Table 16 gives manning levels for the weaving section and for composite units using the U.K., Indian, Romanian and Japanese technologies. The U.K. composite unit provides the lowest employment of 1599. Employment levels associated with technologies from Japan, India and Romania stand at 1684, 1697 and 1735 respectively. The skill composition of the composite technologies varies significantly only for semiskilled labour. Romanian technology has the highest production and maintenance employment of 1315 and 142 followed by Indian, Japanese and U.K. technologies at 1278 and 141, 1274 and 132 and 1199 and 122 respectively. The workshop and managerial staff are the same across technologies, being 40 and 238 respectively.

The total annual power consumption of the U.K., Japanese, Indian and Romanian composite technologies are 25.33 million kWh, 25.89 million kWh, 24.62 million kWh and 25.62 million kWh respectively. Japanese technology is the highest consumer of power. This is because it has a larger loom capacity than the other technologies. The total power consumption also includes air-conditioning (spinning), humidifiers (weaving), lighting, power pump and miscellaneous consumption. These, however, are constant across the technologies.

Intermediate technology

Unlike with modern technology, data on intermediate technology relating to machine speed, expected production, recommended efficiency, manning levels, floor space and power requirement are scarce. Information used in this analysis is based on personal surveys. Both the Rural Fabric Centre (RFC) and the Appropriate Technology Development Association (ATDA) in India use intermediate technology.

For RFC spinning and ATDA roving centres, the selection of machinery is based on production capacity observed under Indian conditions. This can be considered as the expected level of capacity of the subprocess machinery in Bangladesh. The number of machines required is based on material to be processed, which can be calculated using the same method as for the modern sector.

The author's own survey in Coimbatore, India, of an RFC power-spinning unit shows that the spindle production per shift is about 78.24 g (Table 17). Such a unit has spinning frames with 48 spindles. To convert the roving production of a unit into yarn, 42 frames will be required i.e. 2016 spindles in each unit. For 20 RFC units, the total spinning capacity will be 40 320 spindles. A similar survey of 12 ATDA pedal spinners shows that the weighted mean production per spindle of the ATDA pedal charka is 73.14 g/d (table 17). At this rate about 542 pedal spinning frames would be required, each with 12 spindles (i.e. 6504 spindles) to convert roving to yarn for a single ATDA roving centre. Therefore, the total capacity required for 20 units is 130 080 spindles.

The total area of the RFC spinning unit and the ATDA service centre are 26 180 m^2 and 13 800 m^2 respectively. However, if the pedal spinning area is included with the ATDA roving centre, the total spinning area increases to 33 900 m^2. The spinning space required for the composite unit is 25 080 m^2, which is less than the space requirement of the RFC spinning unit as ring finishing area is excluded. Intermediate spinning technology requires twice as much space as modern spinning.

The employment level of the ATDA roving centre with pedal charka is 2.3 times higher than the RFC spinning unit. The employment levels of these technologies are 12 350 and 5430 respectively (Table 18). Intermediate technology has a higher unskilled labour content than the modern. Finally, RFC power and ATDA pedal spinning provide respectively 5 and 12 times more employment than the modern spinning.

The installed power of RFC spinning and ATDA roving centre has been adjusted by factors of 0.74 and 0.8 respectively to estimate the absorbed power. The annual power requirements for 20 (single) RFC spinning and ATDA roving centre are 11.23 million kWh and 3.67 million kWh respectively. As ATDA units produces only roving for the pedal spinners, it has low power consumption. Compared to modern U.K., Indian, Romanian and Japanese spinning technologies, RFC spinning technology uses between 1.12 and 1.27 times more power.

In the RFC composite unit (Indian), only pedal-looms are used. In the present study both pedal- and power-looms are combined with 20 spinning units to obtain 31 million m^2 of cloth. Table 19 shows the number of machines required in the preparatory subprocesses, along with the number of power- and pedal-looms essential to balance a unit.

The pedal-loom production is estimated from the RFC (Coimbatore) and the ATDA (Kushmi Kalan) units. The technical features of the pedal-looms are the same for these two units. The weighted mean production for 10 weavers was found to be 10.3 m^2 per shift. It has been assumed that under Bangladesh conditions, the pedal-loom will achieve this production level. With this calculated production, the number of pedal-looms required for each unit is 550, that is, 11 000 pedal-looms are required to meet the output level of 31 million m^2.

The rated production of power-looms (Table 19) is based on the loom speeds supplied by the manufacturer. The expected production was estimated from the average loom efficiency observed in the five private sector weaving mills in Bangladesh. This is found to be 21.95 m^2 per shift per loom; accordingly 90 power looms will be required per unit to weave all the output (yarn) into grey cloth. Thus a total of 1800 power looms will be required for 20 units to produce 31 million m^2 of cloth.

While the pedal loom runs on a one-shift basis, the power loom runs on a three-shift basis, which means 3.25 times the factory space is required for pedal looms. The total area required for the composite (spinning and weaving) pedal and power-looms is 115 680 m^2 and 55 490 m^2 respectively. Pedal- and power-looms composite units require 5.75 and 2.75 times respectively the floor space that modern composite units do.

Table 20 shows that each of the pedal- and power-looms composite units employ 900 and 487 people respectively. That is 17 950 and 9 750 for 20 units. The RFC composite unit with pedal-loom requires about 1.84 times more workers than the power-loom does. Their requirement of unskilled labour is relatively higher than the modern composite units. Pedal- and power-looms composite units provide between 11.2 and 10.3 and 5.6 and 6.1 times more employment than the U.K., Indian, Romanian and Japanese technologies. The administrative and managerial staff of the intermediate technology is smaller than the modern sector, because its organizational structure is less complex. In India a factory with 200 employees is run by a single manager and three administrative staff.

The absorbed power of the pedal-loom is calculated by using an adjustment factor of 0.75 for spinning and preweaving, while for power-loom, the factors used are 0.74 and 0.8 for spinning and weaving respectively. Annual per unit power requirements of the pedal- and power-looms composite units are 1.19 and 0.64 million kWh, while the total requirements of 20 units are 23.90 and 12.82 million kWh respectively. The power-loom unit, therefore, requires twice as much power as the pedal-loom unit. The power consumption of the power-loom composite unit is not significantly different from the modern composite technologies. The U.K., Indian, Romanian and Japanese composite technologies consume between 3% and 7% more power than the power-loom composite unit.

Before selecting the machinery for three service centres (SCs), it is essential to determine how many centres there should be and of what size, and the number of handlooms to which they may supply input to produce 31 million m^2 of cloth. UNIDO studies show that a production and marketing cooperative could be established with 2000 cottage weaver units located within 8 km (Maldonado, 1976, pp. 15-17). This could include about 4440 looms (assuming 2.22 looms per unit as found in the 1978 handloom census). A service centre could operate in such a cooperative and provide services to 4000 to 4500 looms. Preliminary calculations show that this centre should be able to supply 50 to 60 warp beam per shift with warp length up to 320 m per beam. It is shown later in this section that from 10 636 to 13 824 handlooms are required depending on their types (CR [semi-automatic] or pit-looms) to produce 31 million m^2 of cloth. Thus three service centres are required to supply processed warp beam to these handlooms.

The selection of service centre machines is based on the production and efficiency of the subprocesses observed in the RFC and the ATDA units. The efficiency level ranges from 65% to 70% (observed in India and assumed achievable in Bangladesh). The number of machines determined is shown in Table 21.

The space requirement of the service centre is the same as that of the RFC preweaving. The factory-shed area required per unit is 683 m^2, while the total area for a single unit is 1143 m^2. The manning level per shift of each service centre machine is the same as in RFC preparatory weaving, as subprocess machinery for both technologies are the same. Table 22 shows that each service centre will create employment of 220; a total employment of 660 will be created in three service centres. The annual power requirement per unit is 169.2 thousand kWh. That is, the total requirement of the three units is 507.6 thousand kWh.

The author's own survey, which includes 67 spinners and 13 rovers, was carried out in different parts of India and in a hand-operated unit in Bangladesh. The weighted mean production per shift of the ambar charka rover and spinner is 1.04 kg and 61.52 g respectively (Table 23). The preparatory machinery and hand-operated equipment required for a KVIC spinning unit is calculated from their observed production and shown in Table 23.

A combination of KVIC spinning and handloom forms an alternative technology. A total of 260 KVIC spinning units will be required to produce 31 million m^2 of cloth. The factory-shed and total areas required for the 240 units are 79 680 m^2 and 109 680 m^2 respectively. The total area is nine times larger than that for modern and four times larger than that for intermediate technology. Table 24 shows that the total employment in 240 units is 35 040 which is about 35 and 7 times larger than with modern and intermediate technologies.

The installed power of service centre has been adjusted by a factor of 0.8 to arrive at absorbed power. Annual per-unit power requirement is 15.60 thousand kWh. Thus 3.74 million kWh is required for 240 units to produce 31 million m^2 of cloth. This is one-third the consumption of RFC power spinning and 2% more than the power requirements of ATDA pedal spinning. The KVIC requires between 37% and 42% of the power of modern spinning technologies from Japanese, Romanian, Indian and U.K. sources.

Traditional technology (handloom weaving)

Handloom preparatory subprocesses are labour-intensive. The production capacities of the equipment vary according to the age and skill of the operatives and location of the units. Bobbin making, for example, is usually done by children between 6 and 9 years of age and by elderly members of the family who often work part-time either in family units or for hire. The weighted mean production of preparatory subprocess equipment and handlooms has been established from a survey conducted by the author of 214 handloom cottage weavers in Bangladesh. However, more importance was attached to the weaving production of the two types of looms widely in use in Bangladesh. The pit-loom had a weighted mean production per day per loom of 10.17 m^2 maximum and 7.96 m^2 average. Equivalent figures for the CR-loom were 15.04 m^2 and 10.35 m^2 (Table 25).

The daily production is the maximum that a weaver can accomplish from 06:00 to 22:00 hours, with some time off. Maximum production is usually achieved during the winter (October to February), when demand for the product rises. However, during the monsoons (April to August) production falls to a minimum, as the weavers often engage in agricultural work. The survey was conducted between August and November, when production picks up from its minimum level to the maximum; weavers work mostly for 7 to 9 hours during this time, unlike during the monsoon or winter, when they may work for 4 to 6 hours and 9 to 12 hours respectively.

Among preparatory equipment, only the drum, which makes the warp beam, is placed under the shed, and other preparatory operations are performed in an open or utility area. The utility area is taken to be 10% of the total area. Total areas required for pit- and CR-loom production are 82 282 m^2 and 98 204 m^2 respectively.

Manning requirements of pit- and CR-loom weaving to produce 31 million m^2 of cloth are 21 844 and 18 397 respectively (Table 26). The pit-loom, therefore, requires about 16% more labour than CR-loom weaving. This difference is due to the higher productivity of CR-loom. Manning requirements for weaving preparation are the same for pit- and CR-looms.

Employment of spinning, handloom-weaving and composite alternatives

Table 27 shows the total employment of spinning alternatives, service centre and handloom weaving. It is possible to calculate the total employment of 12 alternatives shown in the table, which were discussed in the previous chapter.

The table also shows that the least employment among composite alternatives is provided by the U.K. technology. Variation in employment among modern composite technologies is not significant; there is only 8.5% between the highest (Romania) and the lowest (U.K.) technologies. The employment provided by combined composite technologies is substantial -- between 5.75 and 33.5 times more than the least-cost (Indian) composite technology.

Input-output balancing

So far, the amount of machinery required by modern, intermediate and traditional technologies to produce 31 million m^2 of cloth has been dealt with. In this section, the input requirements of alternatives is determined for that output. It is necessary to take into consideration wastage rates at the different subprocess levels of modern, intermediate and traditional technologies.

The raw-cotton input of alternatives varies according to subprocess wastage rates. For 31 million m^2, the raw-cotton input for a modern composite unit is 2.89 million kg. For the same output, raw-cotton consumption increases by 2.5% and 3.3% when modern spinning is supplying yarn to service centres or the handloom sector. For intermediate composite units (pedal and power looms), the input requirement increases by about 0.5% over the modern composite unit. On the other hand, ATDA pedal and KVIC spinning require about 4.23% and 5.84% more raw cotton than modern spinning, when supplying yarn to the handloom sector.

Chapter Six

Costing of alternative technologies

To evaluate the efficiency of the 12 alternatives identified in chapter three requires knowledge of their investment and operating costs, which vary across technologies.

Investment costs

The investment costs of spinning, weaving and composite alternatives using modern, intermediate and traditional technologies consist of land and development cost; construction and infrastructure cost; machinery and equipment cost; the cost of working capital; and other costs.

Total investment cost is spread over 3 years. Here costs are discounted to current value. The total investment cost is given at discount rates of 10%, 15% and 20%.

The land requirement and its development are assumed identical for all modern technologies. The land required for a spinning and a composite unit is 6.5 ha and 8.1 ha respectively and the price is BDT 117 600/ha. Land and land development comprises 45% and 55% respectively of the total cost. Thus the total land and development cost for a complete spinning unit is BDT 1.45 million, while for a composite unit it is BDT 1.99 million.

Intermediate technology units are situated near handloom-concentrated areas, so the cost of land is about 50% that of modern technology. The land required per factory unit is 1.2 ha, 1.0 ha, 2.9 ha and 0.2 ha for the Appropriate Technology Development Associations (ATDA) pedal spinning, Rural Fabric Centre (RFC) power spinning, Khadi and Village Industries Commission (KVIC) hand spinning units and Service Centre (SC) respectively. The corresponding land and development costs are BDT 2.21 million, BDT 1.90 million BDT 5.44 million and BDT 0.41 million.

For traditional technology the land requirement is estimated from the loomshed and utility area required for preweaving and weaving. The loom-shed area is based on the floor space required per loom, while the utility area is considered as 10% of the loomshed area. Accordingly, the land required for pit- and CR (semi-automatic)-looms is found to be 9.3 ha and 10.1 ha respectively. The cost of land is estimated to be BDT 32 200/ha, which gives total land cost for pit- and CR-looms of BDT 0.30 million and BDT 0.33 million respectively.

The construction cost for residential buildings, utilities and infrastructure is taken to be identical across technologies. The cost per square metre varies according to the type of construction. For example, the cost for factory shed per square metre is about BDT 2736; for waste godown it is BDT 1645. The total construction cost of Indian, Japanese, Romanian and U.K. spinning and composite units varies from BDT 31.41 million to BDT 32.11 million and from BDT 51.63 million to BDT 52.53 million respectively. For spinning technologies, the variation between the highest (U.K.) and the lowest cost (Indian) is 2.2%, for composite 1.7%.

Construction for intermediate technologies is less robust than for the modern technologies. The estimated cost per square metre for the service centre, ATDA (roving), RFC and KVIC factory units is BDT 1824, while for pedal spinning, which operates at the cottage level, the cost is taken to be BDT 550. The construction cost for ATDA pedal, RFC power and KVIC hand spinning is BDT 28.27 million, BDT 36.80 million and BDT 146.48 million respectively; RFC pedal- and power-loom composite units cost BDT 150.63 million and BDT 72.89 million respectively, and the service centre construction cost is BDT 4.97 million.

In traditional technology the loom shed for a pit-loom will have a mud floor, bamboo walls and thatched roof. In the case of the shed for a CR-loom, the thatched roof would be replaced by tin. The construction cost per square metre is estimated to be BDT 365 and BDT 550 for pit- and CR-looms respectively. The pit- and CR-loom sheds do not have the same lifespan. A survey conducted by the author establishes that they require one and two replacements respectively during 20 years of project life. The pit-loom shed is replaced in the 11th and 18th year, the CR in the 14th. Accordingly, the construction costs for pit- and CR-looms are calculated at BDT 28.65 million and BDT 39.20 million respectively.

All machinery and equipment cost for modern technology occurs at the beginning of the 3rd year when it is brought to the factory for installation.

The total machinery cost in modern technology comprises local and imported machinery cost. For imported machinery, the freight cost shown for machinery from the U.K. is 6% of the FOB price, for the Japanese and Romanian it is 5% and for the Indian, 4%. The imported machinery and equipment costs include, besides CIF cost, 7% import tax and duties, 2.5% landing charge and transportation, 0.5% local agent commission and 3% miscellaneous and other costs to reach the factory sites. For local machinery and equipment, 20% excise duty, 2% transportation cost and 3% miscellaneous and other costs are required at the factory.

In addition to production machinery costs, auxiliary machinery such as the card-grinding and roller-covering machinery for maintenance, testing equipment for quality control, workshop machinery such as lathes, drills and some spares are considered in the total cost. The cost of auxiliary machinery, air-conditioning plant for the spinning units, humidifiers for the weaving sections and electrical substations, all based on the Bangladesh Textile Mills Corporation (BTMC) prices, are the same across technologies, except that the number of humidifiers for weaving sections depends on the number of looms.

The variation in cost for machinery and equipment across Indian, Romanian, Japanese and U.K. technologies is quite significant -- about 46% and 43% for spinning (BDT 83.93 million to BDT 122.22 million) and composite (BDT 182.58m to BDT 251.58 million) units respectively. There is very little difference between the relative cost of spinning and composite units from Indian and Romanian sources when compared with those from the U.K.. This, however, is not so with the Japanese machinery.

The machines common among intermediate alternative technologies have identical unit prices. For RFC and ATDA units, the machines employed up to the roving subprocess are identical. Similarly, between RFC composite and service centre, exactly similar preparatory machines are used, except that the service centre has an extra subprocess by which the warp is transferred to the handloom beam. The machinery for this operation is locally manufactured. For composite units, pedal and power looms are also locally manufactured.

For imported machinery, a freight cost of 4% on the FOB price is taken for RFC, ATDA and KVIC technologies, and 5% for the service centre because of the large space requirement of its sizing machinery. An additional 11.5% on the CIF price accounts for taxes and duties, landing, transportation and miscellaneous costs at factory site. For local machinery, an additional 25% will be added, as has been done for modern alternatives, to the ex-factory cost.

The intermediate technology machines are mostly rebuilt, and they do not have the same life expectancy of modern ones. Author's consultations with manufacturers indicate that modernization of the different subprocesses, especially the drafting system of the RFC roving and spinning frame, is required for the machine life to be the same as modern machinery.

Such modernization is required in the 14th year of the project life. It would involve an additional 75% of the total CIF or ex-factory cost. The total machinery and equipment cost includes auxiliary equipment, spares for two years and modernization.

The machinery and equipment cost of the service centres is BDT 3.82 million. Among spinning alternatives, the RFC power spinning (BDT 68.37 million) has the lowest cost, while ATDA pedal (BDT 83.95 million) and KVIC spinning (BDT 93.63 million) cost 22.80% and 36.95% more than RFC spinning. KVIC spinning costs 8% and 12% more than Romanian and Indian spinning but 15% and 31% less than Japanese and U.K. spinning respectively. All other intermediate spinning alternatives have between 19% and 56% less machinery cost than modern spinning. The RFC pedal (BDT 145 million) and power (BDT 125.44 million) composite units cost between 29% and 50% less than modern alternatives.

Unlike modern and intermediate technologies, the equipment and looms of traditional technology are all manufactured by local carpenters, tinsmiths and workshops. Their cost does not, therefore, include any taxes or duties.

The pit- and CR-looms have relatively shorter lifespans than the machines of modern and intermediate technologies. This means the pit- and CR-looms will need a series of replacement investment to make the timespan of their production flows comparable to that of modern and intermediate technologies. Thus, the pit-loom needs to be replaced in the 9th, 14th and 19th years and the CR-loom in the 14th year. The local machinery and equipment cost of pit- and CR-looms are BDT 18.18 million and BDT 30.01 million respectively, which indicates that the CR-loom costs about 65% more than the pit-loom. These costs include an additional 6.5% on loom prices to account for sizing equipment and 1 year's spares and accessories.

Installation and other costs for modern factories are estimated from data on the new mills currently under construction by the BTMC. They are about 3% of the CIF cost of the imported machinery. Administrative and management costs are assumed to be similar for spinning and composite units. Administrative overhead is 10% of administrative salaries. Finally, a contingency fund of 5% of the total cost is included. Installation and other costs of modern spinning and composite units vary between BDT 5.70 million and BDT 6.99 million, and BDT 10 million and BDT 12.47 million respectively.

Installation and other costs for intermediate-technology production units in which almost all machinery is imported are taken to be 3% of the CIF cost. The ATDA pedal and ambar charka frames do not need foundation work; therefore, installation costs are only 1% of their purchase price. Administrative overhead costs and contingency allowances are assumed to be the same as those of the modern sector -- 10% of administrative salary and 5% of local investment cost. Installation and other costs of ATDA pedal and power and KVIC hand spinning are BDT 3.53 million, BDT 5.14 million and BDT 13.47 million respectively; RFC pedal and power composite unit costs are BDT 16.18 million and BDT 11.24 million respectively, and service centre costs are BDT 0.6 million.

The traditional looms require very little transport and installation costs, normally amounting to not more than 1% of the total cost of equipment. The installation and other costs of pit- and CR-looms are BDT 0.18 million and BDT 0.29 million respectively.

Working capital is needed to finance the stock of raw materials, material in the processing stage, finished goods, stock of spares and accessories and cash in hand. The time taken for processing the raw materials depends on efficiency of labour and the machinery and the technology applied. On the other hand, the stock level of finished goods depend on the market for which it is manufactured and on the marketing strategy. Finally, the amount of cash in hand is a function of wages and salaries and miscellaneous payments (NEI, 1980, p.47; Pickett and Robson, 1981, p.51). For modern spinning and composite textile units, one should assume a 26-week supply of raw cotton, 3 weeks' worth of work in hand and a 2-week inventory of finished goods. There needs to be a 26-week stock of imported spares and a 4-week stock of local spares. Cash in hand should cover one month of salaries and wages.

The total working capital required for modern spinning and composite technologies varies between BDT 19.67 million and BDT 19.87 million and BDT 23.78 million and BDT 23.84 million respectively. Variations in working capital between the technologies is not significant (about 1% and 1.6% in spinning and composite alternatives respectively). However, composite units require 20% to 23% more working capital than the spinning alternatives. The U.K. technology requires the highest working capital followed by technologies from Japan, Romania and India.

For intermediate technology, the stocks of raw cotton and finished goods are assumed to be identical to those of modern technology, whereas the material in progress is reduced from 3 to 2 weeks for ATDA and RFC power spinning and composite weaving and 1 week for pedal and KVIC spinning. A subsequent reduction in the processing time is based on author's observations of ATDA and RFC units in India. Spares are supplied entirely from local sources, and their stock level must be enough for up to 4 weeks, as in the modern sector.

The total working-capital requirements are for ATDA pedal spinning BDT 17.25 million, for RFC power spinning BDT 17.97 million, for KVIC hand spinning BDT 18.18 million, for RFC pedal composite BDT 21.87 million, for RFC power composite BDT 21.42 million and for service centres BDT 10.61 million. Variation in working-capital requirements among spinning alternatives is significant, about 5.4%; for RFC composite units with pedal- and power-looms it is almost identical. Both intermediate spinning and composite units have significantly lower working-capital requirements than the modern alternatives.

Sen (1969, pp. 101-102) notes that the working capital required for handloom units depends mainly on the time that elapses between the arrival of the input material for the looms and the receipt of the proceeds of the cloth sold. The magnitude of the lag depends not merely on the technical speed of production but on marketing lags. He sees a difficulty in measuring this lag, which he assumes to be 3 months. The handloom survey carried out for this study observed that the working-capital requirement relies heavily on the length of the warp beam. Longer warp beam means that more money is tied up in the loom. It is further observed that handloom weavers somehow succeed in raising the money to purchase the total yarn for the warp beam. Once the entire warp beam is installed, they take the finished output off from the cloth beam twice a week.

To estimate the working capital required, it is essential to make some assumptions about the source of input, total yarn requirement and the marketing lag involved. For the purpose of this study, it is assumed that handloom weavers buy their yarn from the Bangladesh Handloom Board (BHB)'s distribution centre and pay an additional 10% on mill price to cover transportation and distribution costs. The output is sold in the local market or to BHB (Bangladesh, 1988a, p. 44). It is also assumed that any interim payments received would go to hired hands, spares and other costs as necessary.

To calculate working capital, it is essential to know the quantity of yarn in a warp beam, which depends on the length of warp beam and construction of the grey cloth. The cloth construction is already specified. The length of the warp for pit- and CR-looms averages 180 m and 270 m respectively. The working capital for these looms is therefore assumed to be the total cost required to install a full tana or beam (processed warp) in the looms. The cost of the full beam consists of yarn cost, plus 20% for sizing materials and other costs.

Total working-capital requirements of pit- and CR-looms are BDT 8.41 million and BDT 11.35 million respectively. CR-looms require 35% more working capital than pit looms, because of their larger warp length.

The total investment cost of alternative technologies can be obtained by discounting the five cost elements. The total cost is calculated using three discount rates -- 10%, 15% and 20% per annum (Islam, 1985, p. 215). However, the ensuing discussions are based on a 15% discount rate.

Table 28 summarizes the total investment cost. At a 15% discount rate the U.K. technology incurs the highest capital cost, followed by the Japanese and Romanian technologies. The investment requirement decreases from the U.K. to Japanese, Romanian and Indian by 8.5%, 20.1% and 22.4% respectively. The table shows that the KVIC hand spinning requires about 2.05 and 2.13 times more investment than ATDA and RFC spinning. It also requires between 52% and 94% more investment than the U.K., Japanese, Romanian and Indian modern technologies. On the other hand, RFC power and ATDA pedal spinning require respectively from 8.4% to 27.8% and from 4.9% to 25.97% less investment than modern spinning technologies. At a 15% discount rate, the CR-loom has 45% more investment cost than the pit-loom. The service centre, which replaces traditional preparatory weaving, has at a 15% discount rate a total investment cost of BDT 20.42 million. Pit- and CR-looms, combined with service centres, have an increase in investment cost of 31.7% and 23% respectively.

The table shows the total investment cost of modern composite alternatives. The investment cost ranking at a 15% discount rate is identical to modern spinning alternatives, with U.K. technology having the highest cost, followed by the Japanese, Romanian and Indian. The fall in investment requirements is 17.5%, 20.9% and 23.0% respectively. At a 15% discount rate, the pedal-loom composite unit requires 44.2% more investment cost than power-loom weaving. It has an investment cost of 27.6%, 24.3% and 19.2% more than the Indian, Romanian and Japanese modern technologies respectively, but 2% less than the U.K.

It appears from the table that the first five combined alternatives require 11.8% to 39.3% and 4.4% to 40.0% less investment cost than modern and RFC composite technologies. The alternative that combines KVIC hand spinning and pit loom, however, requires the highest cost among all composite alternatives.

Salvage values

The salvage values of modern, intermediate and traditional technologies were determined from information collected from the BTMC, private mills and the handloom survey.

The salvage values for modern technologies are composed of 100% of land value, 50% of building costs, 7.5% of the machinery and equipment cost and 100% recovery of the working capital (NEI, 1980, p.51). The salvage values for U.K., Japanese, Indian and Romanian technologies are, respectively, BDT 69.97 million, BDT 68.0 million, BDT 65.04 million and BDT 65.72 million for spinning and BDT 139.67 million, BDT 138.65 million, BDT 136.84 million and BDT 138.88 million for composite units respectively.

For intermediate technologies, the salvage values include 100% of land value, 25% of building cost and 100% recovery of the working capital. As the machinery was rebuilt, it is assumed it would have no salvage value at the end of the project life. The salvage value of the service centre is BDT 20.81 million, while for ATDA pedal, RFC power spinning and KVIC hand spinning, it is BDT 37.30 million, BDT 46.92 million and BDT 90.96 million respectively.

The salvage values of RFC composite units with pedal- and power-loom are respectively BDT 94.72 million and BDT 66.23 million.

The salvage values of traditional technologies come only from land and the recovery of the working capital. The salvage values of pit- and CR-looms are BDT 11.12 million and BDT 13.4 million respectively.

Operating costs of alternative technologies

The operating cost is disaggregated into five cost components. These are: raw-material cost; labour and administration cost; spares and accessory cost; power, fuel and water cost; and other costs. This cost builds up from the start-up time (3rd year) to the full production-level stage (6th year).

As the actual productivity fell below the expected or manufacturer's recommended level (chapter four), to attain the output level of 31 million m^2 of cloth, the number of working days for the alternatives are, therefore, increased. Operating cost is calculated for actual and expected productivity levels to enable evaluation of alternatives at both productivity levels. However, the ensuing cost comparison among alternatives is analyzed for actual productivity level only.

Raw material cost

The raw-material cost for modern composite units covers raw cotton and sizing materials, whereas for spinning units it excludes sizing materials. The raw-cotton requirement varies across technologies because of differences in wastage. The total raw-cotton requirement is met by fresh, raw cotton of 2.697 cm staple length (80%) and usable, waste cotton (20%). The overall wastage for spinning units is about 12.86%. Of the total wastage, 40% is unusable and 60% is salable in the market.

The raw cotton is almost entirely imported. The CIF and ex-factory prices of fresh and usable cotton are BDT 12.08 and BDT 6.0/lb. (BDT 26.63/kg and BDT 13.23/kg) respectively. Fresh raw cotton is subject to, besides the CIF cost, 3.5% import duty and 20% sales tax. Landing, transportation and miscellaneous expenses are estimated to be 3.5% of the CIF price. However, the price of waste cotton includes all these costs. The cost of sizing materials for composite units is taken to be 3% of the raw cotton cost.

The raw-material cost for spinning alternatives is the same across technologies at actual and expected productivity levels. For yarn supplied to service centres, handlooms and composite units, the costs are BDT 88.11 million, BDT 88.78 million and BDT 90.48 million respectively.

The raw-cotton requirement for intermediate spinning and composite units varies according to the wastage rates at different subprocesses. The overall wastage found for RFC power spinning is 12.86%, while for ATDA pedal and KVIC spinning, the wastage rates are 13.70% and 14.55% respectively. The raw cotton is subject to the same taxes and duties and other miscellaneous costs as for modern spinning. The sizing cost of RFC composite units is the same as that of modern composite units.

The yarn requirement of the service centre is based on the output level of 31 million m^2 of cloth. The selling price of yarn obtained from the BTMC is BDT 55.40/kg including BDT 0.77 as excise duty. It is assumed that the service centre would get its yarn supply from BHB at 5% higher than the mill price to accommodate distribution and other costs. It also includes another 2% on yarn cost for sizing materials. The raw-material cost is BDT 150.31 million for service centres; BDT 89.65 million, BDT 88.78 million and BDT 90.53 million for ATDA pedal, RFC power and KVIC hand spinning units respectively; and BDT 90.92 million for both pedal- and power-loom composite units.

The raw-material costs of modern and intermediate spinning alternatives is not significantly different, KVIC hand spinning having the highest cost. For composite units, modern and RFC technologies have almost the same cost, as their wastage levels are identical.

The raw-material costs in traditional technology include the cost of yarn input, sizing materials and transportation and distribution costs. The yarn supply to this sector will be from modern, intermediate and KVIC spinning mills. The amount of yarn processed in handloom weaving is estimated to provide a total annual output of 31 million m^2 of cloth. It is assumed that BHB would purchase and distribute the yarn to handloom weavers.

The survey conducted by the author establishes the cost of sizing materials to be about 3% of the yarn cost. Transportation and distribution costs are assumed to be 10% and 5% when yarn is supplied from modern and intermediate spinning respectively. Distribution costs of intermediate spinning are lower because these units are located near handloom areas.

Yarn and sizing costs for pit- and CR-looms are similar at BDT 160.65 million as both operate with same wastage rates. If the supply source is intermediate spinning, then the cost is reduced by 5% to BDT 152.93 million because of lower transportation and distribution cost.

Labour and administration costs

The total annual wage cost is estimated on the basis of 300 working days. For U.K., Japanese, Indian and Romanian technologies, wages and salaries cost BDT 8.27 million to BDT 8.99 million for spinning and BDT 13.36 million to BDT 14.54 million for composite units. The variation in wages and salaries cost across technologies is minimal for modern spinning and composite units. For spinning, the cost differential between the highest (Romanian) and the lowest (U.K.) is only 7.3%, while for composite units, this differential is even lower, only 5.4%. Among spinning technologies, the Japanese has the lowest wage cost, while for the composites it is the U.K. technology.

Wage and salary costs are BDT 64.48 million, BDT 37.47 million and BDT 118.74 million for ATDA pedal, RFC power and KVIC hand spinning respectively, BDT 99.48 million and BDT 61.59 million for RFC pedal and power loom respectively, and BDT 3.57 million for service centre.

Among intermediate spinning, the RFC power spinning has the lowest wage and salary cost while ATDA pedal and KVIC hand spinning have almost 1.9 and 3.6 times more cost than RFC power spinning. The wage and salary cost of modern spinning is significantly lower than that of intermediate spinning. For example, RFC power spinning has between 4.13 and 4.43 times more cost than the Romanian, Indian, Japanese and U.K. alternatives. On the other hand, power looms have 36.78% less wage and salary cost than pedal looms, but between 4.48 and 4.73 times more cost than modern composite alternatives.

The total wage cost of pit-looms (BDT 69.13 million) is marginally higher than that of CR-looms (BDT 68.36 million), by 1.13%.

Spares and accessory costs

The author's survey of 17 modern textile mills shows the annual spares cost to be 2% of the CIF price of imported machines and 3% of the ex-factory price of local machines. The imported spares cost at factory site includes CIF cost, 15% import duty, 2.5% landing and transportation cost and 2.5% miscellaneous and other costs. For local spares, an additional 25% on ex-factory cost is required, which comprises 20% excise duty, 2% transportation cost and 3% miscellaneous and other costs.

The annual spares cost for spinning units varies between BDT 3.35 million and BDT 4.74 million and between BDT 3.38 million and BDT 4.77 million when supplying yarn to service centres and handlooms respectively; and between BDT 6.62 million and BDT 9.34 million for composite units by technologies from India, Romania, Japan and U.K. The spares cost would increase by 45.6% for the spinning unit that supplies yarn to service centres and handlooms if the technology is U.K. instead of Indian. In composite production, the spares cost for U.K. technology is about 43.10% higher than for Indian technology.

For intermediate technology, the annual spares consumption is estimated to be 3% of both CIF and ex-factory cost. All spares for intermediate technology are locally manufactured. The cost of spares includes ex-factory price plus 25% for excise duty (20%), transport (2%) and miscellaneous (3%). Spares cost is BDT 0.17 million for the service centre, BDT 5.26 million for ATDA pedal, BDT 3.54 million for RFC power, and BDT 7.51 million for KVIC hand spinning, and BDT 6.50 million and BDT 5.71 million for RFC pedal- and power-loom units respectively.

RFC power spinning has the lowest spares consumption cost in intermediate technology. It is, however, higher than modern Indian and Romanian spinning. ATDA pedal and KVIC hand spinning have significantly higher spares costs than all modern spinning. RFC pedal-loom has about 15% more spares cost than the power-loom. Spares costs in intermediate technology do not vary significantly from those of modern composite technologies, except for U.K. technology.

The author's handloom survey shows that the spares cost varies for different loom types as well as for the same kind of looms. The average annual spares and repair cost is BDT 180 and BDT 225 for pit- and CR-looms respectively. This is 20% (pit-looms) and 7.5% (CR-looms) of the loom price. The spares costs of pit- and CR-looms are BDT 2.47 million and BDT 2.39 million respectively.

The pit-loom has about 4.18% higher spares cost than the CR-loom. The spares cost of traditional technology includes fuel and lubrication cost (handloom technology uses kerosene oil and wax for lubrication).

<u>Power, fuel and water</u>

The rated power consumption of the modern spinning and weaving sections is multiplied by 0.89 and 0.94 respectively to obtain the actual power consumption. The total cost of power consumption is calculated by taking the cost per kWh to be BDT 1.05. The total power and fuel cost of Indian, Romanian, Japanese and U.K. alternatives varies between BDT 10.14 million and BDT 11.69 million for spinning and between BDT 27.93 million and BDT 28.87 million composite technologies.

In the intermediate technology, power costs are calculated on actual productivity. These are BDT 4.05 million for ATDA pedal spinning, BDT 13.14 million for RFC power spinning, BDT 4.22 million for KVIC hand spinning, BDT 14.54 million for RFC pedal-loom, BDT 25.83 million for RFC power-loom and BDT 0.59 for service centre. The power cost of ATDA pedal and KVIC hand spinning is one third of the RFC power spinning. The power cost for pedal-loom composite units is 55% that of the power-loom, as a number of subprocesses of this alternative are manually operated.

<u>Other costs</u>

Other costs include administrative overhead, office and factory maintenance and miscellaneous expenditure. Administrative overhead in modern technology is estimated to be 20% and 30% of administrative salaries at actual and expected productivity levels respectively. Office and maintenance costs are estimated to be BDT 700 000 for composite and BDT 400 000 for spinning units respectively; these are assumed to be identical for all technologies. The miscellaneous cost is estimated to be 2% of the total labour and administrative costs.

Other costs for modern spinning alternatives vary from BDT 1.01 million to BDT 1.11 million and for composite units from BDT 1.61 million to BDT 1.63 million. The difference in other costs between spinning and composite alternatives is not significant.

The administrative overhead for service centre, ATDA pedal, RFC power spinning and composite unit with pedal- or power-looms is taken as 10% of administrative salaries. The miscellaneous cost of RFC spinning and composite units is 1% of the total wages and salaries cost, while for service centre and ATDA pedal spinning it is 10% of the administrative salaries. The administrative overhead and miscellaneous costs for KVIC spinning are together taken to be BDT 3500 per unit. The repair and maintenance cost is estimated per factory unit. These costs for service centre, ATDA pedal and RFC power spinning are BDT 30 000, BDT 10 000 and BDT 20 000 per unit respectively. For composite pedal- and power-loom units, these are BDT 75 000 and BDT 45 000 per unit respectively.

Other costs are BDT 0.04 million for service centre; BDT 0.48 million, BDT 1.15 million and BDT 1.52 million for ATDA pedal, power and hand spinning respectively, and BDT 3.19 million and BDT 2.21 million for RFC pedal- and power-loom respectively.

To accommodate incidental expenses and repairs of the working shed in traditional technology, a fixed amount is taken for maintenance and miscellaneous costs. This is estimated for pit- and CR-looms to be BDT 15 and BDT 20 per loom respectively, for a total of BDT 0.21 million and BDT 0.22 million respectively.

Total annual operating costs

The total operating cost of alternative technologies can be obtained by combining all the cost elements discussed above. These costs will reach the maximum in the 6th year and thereafter will remain at that level for the balance of the project life.

Table 29 shows the annual operating cost of modern and intermediate spinning and composite and traditional weaving alternatives.

When supplying yarn to service centres, the U.K. technology has the highest cost of BDT 113.94 million, followed by the Indian (BDT 112.88 million), Romanian (BDT 112.68 million) and Japanese (BDT 111.69 million). The difference in the operating costs is not so significant -- only 2.01% between the U.K. and Japanese technologies. When supplying yarn to handloom weavers these costs increase marginally; again the differential in cost is less significant -- only 2.0%. At expected productivity level, the operating cost decreases as shown in the table.

The table shows that the total operating costs of ATDA pedal (BDT 163.93 million) and KVIC hand spinning (BDT 222.53 million) at both expected and actual productivity levels remain the same, as productivity levels are also same. At actual productivity levels, RFC power spinning has the lowest operating cost (BDT 138.91 million) of all intermediate spinning alternatives, being 12.10% and 35.25% lower than ATDA pedal and KVIC hand spinning respectively. The operating cost of intermediate spinning at actual level can be compared with the costs of modern-spinning technologies, all of which supply yarn to handloom weavers. ATDA pedal, RFC power and KVIC hand spinning cost 42.8% to 45.7%, 25.6% to 28.1% and 93.9% to 97.8% more respectively than the U.K., Indian, Romanian and Japanese technologies.

The table shows annual operating costs for pit- and CR-looms are BDT 224.74 million and BDT 223.89 million respectively. These are lower when the supply of yarn comes from intermediate spinning than when it comes from the modern sector. This decline of about 5% comes entirely from the decrease in transportation and distribution costs. The operating costs of these two looms do not vary significantly, only by 0.37%. The raw-material cost, which is about 70% of the total operating cost, is the same for both. Other major costs also do not vary noticeably as the preparatory subprocesses are common for both types of loom, and weaving payments are made on the cloth woven.

The annual operating cost of the service centre is BDT 154.67 million. The operating costs of pit- and CR-looms decrease by about 8.4% when processed beam is supplied from the service centre.

The table also shows the annual operating costs of modern composite alternatives. The U.K. composite technology has the highest operating cost (BDT 143.27 million), the Indian (BDT 140.48 million) the lowest. Their cost differential is not significant -- about 1.62%.

The operating costs of RFC composite pedal- and power-looms are BDT 214.62 million and BDT 186.25 million respectively. At actual level, the pedal-loom has about 15.23% more cost than the power-loom. The RFC composite unit has operating-cost requirements for pedal- and power-looms that are 30% to 32.1% and 49.8% to 52.3% higher than those of the U.K., Romanian, Japanese and Indian composite technologies.

The table shows, at actual and expected levels of productivity, the annual operating cost of combined alternatives. The combined alternatives have between 31% and 218% more annual operating cost than modern alternatives. The RFC power-loom composite unit has the lowest annual operating cost among all combined alternatives, yet requires between 30% and 32% more cost than the modern alternatives. The higher operating costs of the combined alternatives are due to their having a larger labour complement than modern and intermediate alternatives.

Chapter Seven

Evaluation and analysis

This chapter evaluates the alternative technologies using the discount cash flow (DCF) method. The evaluation first identifies the least-cost spinning among the modern alternatives and the most-efficient handloom among the traditional ones. It then deals with the twelve composite alternatives selected earlier, some of which, it will be recalled, combine least-cost spinning and traditional handloom technology.

The criteria to rank the alternatives are present value cost (PVC), net present value (NPV) and present value cost per unit (PVC/unit) output. The capital-labour cost (K/L) of the alternatives has also been calculated. This indicates the investment intensity of the alternative technologies.

The cost of capital used in the evaluation is important as distortion of this is widespread in the developing countries. In 1981, the interest rate of the Bangladesh Bank (the central bank) was 10.5%, while for industrial finance the interest charged by the investment banks was 14%. The appraisal of public sector projects by the Planning Commission of Bangladesh used two discount rates of 10% and 15%. The Bangladesh Textile Mills Corporation (BTMC) used identical discount rates to examine the feasibility of the projects. The present study uses three discount rates, 10%, 15% and 20% (Islam, 1985, pp 241-262). However, the ensuing discussions are based on a 15% discount rate.

Although the 12 technologies are complete textile processes (i.e. they combine spinning and weaving), it is essential to examine spinning separately because of the need to combine least-cost spinning technology in the modern sector with Service Centre (SC) or handloom weaving and to examine the efficiency ranking between modern and intermediate spinning alternatives. Accordingly, the spinning technologies of U.K., Japan, India and Romania are examined to identify the least-cost spinning. And the ranking of all modern, Appropriate Technology Development Association (ATDA) pedal, Rural Fabric Centre (RFC) and the Khadi and Village Industries Commission (KVIC) hand spinning alternatives is examined.

K/L, PVC, NPV and PVC/unit of alternative spinning technologies

Indian spinning is the least-cost among the modern and the intermediate alternatives. It is also evident that all the modern alternatives are economically more efficient than the intermediate spinning alternatives. Among intermediate technology, RFC power spinning emerges as the most efficient followed by ATDA pedal and KVIC hand spinning. The ranking of the technologies is insensitive to the change in discount rate and therefore the ensuing discussion has been based on a single discount rate of 15%.

Table 30 shows that among the modern alternatives, the second-best (Romanian) technology has the lowest K/L cost followed by the least-cost (Indian) spinning. The variation in K/L cost of the modern alternatives is significant. For instance, the capital-labour costs of the Japanese and the U.K. technologies are about 17.0% and 25.15% higher than that of the least-cost. On the other hand, the K/L cost of intermediate spinning alternatives is low compared to the least-cost technology. The K/L cost of the least-cost is 6.7, 14.62 and 20.0 times higher than RFC power, ATDA pedal and the KVIC hand spinning technologies respectively.

The Indian PVC is about 0.5%, 3.04% and 6.72% less than the Romanian, Japanese and U.K. modern spinning technologies. The RFC power, ATDA pedal and the KVIC hand-spinning have PVCs that are 19.15%, 32.37% and 95.52% respectively higher than the least-cost technology.

Among the alternative sources of modern spinning, RFC power, ATDA pedal and the KVIC technologies have negative NPVs including the least-cost. It appears, therefore, that yarn production in spinning mills to sustain handloom employment generates inefficiency. To promote economic growth, the investment should be economically efficient. These results indicate that expansion of each spinning unit with 25 000 spindles (the unit size considered for this study), irrespective of the machinery sources and intermediate spinning alternatives, is economically inefficient and requires subsidy.

PVC/unit for alternative spinning technologies shows the increase in cost over least-cost technology. At a 15% discount rate, the increase in unit cost between least-cost and the second-best technology is marginal (0.56%), while for the Japanese and U.K. alternatives it is more significant at 3.15% and 7.22% respectively. The unit-cost differential increases substantially between least-cost and the intermediate alternatives. The PVC/unit cost of RFC power, ATDA pedal and the KVIC hand spinning is about 19.26%, 32.59% and 95.74% more than the least-cost technology.

The table shows the employment level of modern and intermediate spinning alternatives. The second-best (Romanian) technology provides the highest employment of 1046 followed by the least-cost (Indian), Japanese and the U.K. The difference in employment level is not so significant. The Romanian technology provides about 3.76% more than the least-cost of 1008, while the Japanese and the U.K. generate about 2.18% and 3.57% less employment. However, the variation is more pronounced for intermediate technologies. The RFC power, ATDA pedal and the KVIC hand spinning create employment that is 5.32, 12.25 and 34.76 times more respectively than the least-cost technology.

The trade-off between employment and efficiency is analyzed by calculating the PVC in excess of minimum and the increase in employment over the least-cost technology. Table 30 also gives the cost of additional jobs created compared to the least-cost technology. Among the modern alternatives only the second-best technology provides the possibility of employment expansion (BDT 74 740 per additional job). As the absolute increase in the number of jobs that would result from choosing the Romanian rather than the Indian spinning technique is 38, there is perhaps no great cause here for excitement. The Japanese and the U.K. technologies have higher PVCs than the least-cost but at the same time generate less employment. Therefore these technologies are not worth considering for employment expansion.

Although KVIC hand spinning appears from the table to be an attractive option for employment expansion, its PVC is higher than the minimum and represents 195% of the least-cost option PVC. Its PVC in excess of minimum is BDT 579.98 million and so is about 3.6 times the investment cost of the least-cost spinning technology. Therefore, from economic considerations, the most labour-intensive technology is not worth considering as an option. The trade-off could be improved by considering RFC power and ATDA pedal spinning. RFC power has about 19% more PVC and about 81% of the investment cost of the least-cost spinning. ATDA spinning has about 32.4% more PVC and about 84% of the investment cost of the least-cost spinning. Of these two the RFC power spinning is a better option for efficiency.

The yarn price used to calculate NPVs for 32s cotton count has been taken from the BTMC. The yarn price is under direct control of the government and the ex-factory price of yarn is the same for all mills irrespective of yarn quality and the location of the mills. Therefore, the mills that are away from seaports incur extra costs for transport and other expenditures. Such variations in input costs would be reflected in the unit cost, but the fixed yarn price ignores such factors. This study, however, considers the location of units in the central region of the country and minimizes the impact of cost differentials.

The absence of a cost-plus approach to pricing yarn reflects government policy to subsidize and help sustain handloom weaving and the employment it generates at present (IBRD, 1982, p.111; 1983, p. 65). In other words, the policy to expand the spinning capacity only for the supply of yarn to the handloom weavers at a considered price (1981) of yarn is a cost to the economy that affects economic growth. It is appropriate here if the yarn price of the particular count used for this study is taken from the Indian price. The ATDA yarn price for 32s cotton count is BDT 69.63/kg, which is in fact about 27.72% higher than the Bangladesh ex-factory price. If this yarn price is considered to be the selling price of yarn in Bangladesh, then the profitability of alternative spinning increases substantially, especially for the modern sector. At that price, all modern spinning alternatives generate surplus. For example, the profitability of the least-cost technology increases at discount rate of 15% from a negative NPV to surplus of BDT 89.68 million. RFC power spinning ceases to be loss-making, generating surpluses of BDT 15.57 million. Although the NPVs of ATDA pedal and the KVIC hand spinning naturally rise with price, these techniques remain substantial loss makers.

__PVC, NPV and PVC/unit at expected productivity levels__

In this section the alternative spinning technologies are re-evaluated on the basis of expected or manufacturer-recommended levels of productivity. The expected level of productivity assumes the minimization of inefficiencies that result from poor management or other reasons. Such improvement in productivity shows an increase in efficiency of modern spinning, but no change in the ranking of alternatives. It should be noted, however, that the productivity levels of ATDA and KVIC hand spinning remain unchanged; therefore, their PVC, NPV and PVC/unit remain the same.

Table 30 shows the PVC, NPV and the PVC/unit of alternative spinning technologies at expected productivity levels. It indicates that the ranking of the technologies remains unchanged at expected levels of productivity. Indian spinning remains the least-cost technology. The PVCs of the alternatives, however, decrease with the increase in productivity. For the least-cost and the second-best (Romanian) technologies, the PVCs are about 1.66% and 1.30% less than at actual productivity level. The PVC in excess of minimum between least-cost and the second-best technology increases from about 0.5% to 1% at expected productivity level. This increases the advantage of the least-cost technology in cost per additional job, but not significantly. The U.K. remains the highest-cost technology, followed by the Japanese.

The PVC of RFC power spinning, at expected productivity level, has the greatest reduction of 3.08%, which reduces the cost per additional job compared to the least-cost spinning from BDT 26 460 to BDT 23 600. Therefore, at expected productivity level, the relative efficiency of the least-cost technology increases compared to the other spinning alternatives.

At a 15% discount rate and above, all spinning alternatives have negative NPVs. However, due to increases in productivity, there has been some reduction in losses. Losses of modern spinning reduce 12.2% to 38.6%. Least-cost spinning attains the greatest reduction, followed by Romanian, Japanese and U.K. The loss of RFC power spinning reduces by 15.1%, about 3% more than Japanese and U.K. technologies. Increase in productivity, in fact, makes the least-cost technology more attractive compared to other alternatives

PVC/unit of spinning alternatives at expected productivity level shows that only RFC power spinning increases its acceptability. Its differential in unit cost with the least-cost technology decreases from 19.26% to 17.70%. On the other hand, the differential in unit cost between least-cost and the second-best technology increases marginally (0.28%), while for the Japanese and U.K. technologies the differential increases by 0.78% and 0.5% respectively.

Handloom-weaving technologies

Two kinds of handloom weaving -- pit and CR (semi-automatic) -- that are widely used are considered in this study. Types of pit-loom vary considerably across the country, and this is reflected in their prices. A pit-loom could cost as little as BDT 400. The type of pit-loom considered in this study costs BDT 900. This loom would be able to carry a processed warp-beam (12.3 kg of processed yarn) from a service centre. Processed warp-beam is already in use in the KVIC type unit (Charka and Cottage Industries Organization, Comilla, Bangladesh) which has been surveyed by the author for this study. However, the preparatory weaving machinery of this unit is operated manually. Before the looms are combined with the optimum or the least-cost (Indian) spinning to form a complete process technology, it is necessary to establish the efficient handloom among the alternatives. Three inputs for handloom weaving are considered: yarn from modern spinning, yarn from intermediate spinning located near the handloom areas and yarn beam from the service centre. The loom that emerges as efficient would be combined to form composite alternative technologies.

It is assumed that the input cost of yarn for handloom weavers is the common ex-factory price irrespective of the source of supply. However, transportation and other costs vary according to source. Distribution and other expenses are 10% above the ex-factory price for modern spinning and 5% for intermediate spinning and service centres near the handloom areas.

Table 31 shows that the PVC of pit- and the CR-looms, when receiving processed warp beam from the service centre at a 15% discount rate are BDT 944.94 million and BDT 967.69 million, and their employment levels are 17 218 and 13 771 respectively. If the yarn is supplied by RFC power spinning, the PVCs of pit- and the CR-looms increase by 3.34% and 3.18% respectively, while the employment increases by 4626 for both looms. Finally, when the yarn source is modern spinning (Indian), the PVCs increase by 3.08% and 6.52% for pit- and 3.0% and 6.28% for CR-looms compared to when yarn is supplied from RFC spinning and the service centre respectively. Actual and expected levels of productivity are assumed to be the same.

The NPVs of pit and the CR-looms at 15% discount rate shows that both the looms have negative NPVs when yarn is supplied from the modern sector. Therefore, at the ex-factory price of yarn, which is already subsidized, as has been established in spinning, both the looms are economically inefficient. The acceptability of the pit-loom increases when the supply source is intermediate (RFC spinning), while the CR-loom remains inefficient. This increase in efficiency of the pit-loom is the result of a 5% lower distribution cost than intermediate spinning. An actual increase in efficiency of pit- and CR-looms is evident when processed beam is supplied from the service centre. In such a case, looms generate surplus at all discount rates.

The PVC/unit increases progressively for pit- and the CR-looms if input sources are intermediate and modern rather than service centre. At a 15% discount rate, the unit cost of pit-looms increases by 3.3% (intermediate)and 6.6 (modern). The equivalent figures are 3.1% and 6.3% for CR-looms.

The yarn price paid by handloom weavers is an important element in the competitive cost of production with the modern sector. This is apparent in the above when the supply source is RFC power spinning at 5% less than the modern sector. It may be added here that handloom weavers at present face about a 30% higher cost for yarn than the ex-factory price, a fact which contributes significantly to the inefficiency of this sector.

The pit-loom emerges as the efficient option irrespective of the input source, while the CR-loom has not only a higher PVC, but also a lower employment level. Moreover, pit-loom requires less investment per employee. However, the pit-loom is at a quality disadvantage as its yarn breakage is relatively higher than that of the CR-loom.

It is clear that the most cost-effective techniques combining modern and traditional methods would be modern Indian spinning, service centres and the pit-loom. This has, however, to be appraised against wholly modern alternatives and RFC composite weaving. It is, moreover, convenient to consider some of the alternatives already rejected. This applies particularly to the CR-loom. This loom is widely used in Bangladesh and accounts for some 23% of handloom capacity. It and other rejected alternatives provide much more employment than modern techniques, so that it is important to have a comprehensive picture of the cost at which they could do this.

K/L, PVC, NPV and PVC/unit of alternative composite technologies

The basic input for all the textile alternatives is raw cotton. But the real cost of yarn as it goes to be woven in the integrated process is not normally the same price as that fixed by government. Using actual cost, however, removes any bias the fixed price has in favour of particular spinning and weaving techniques. The price of yarn to a composite mill and to a handloom weaver could still differ because of distribution costs. These, however, must be accurately recorded if an economic calculation is to be sound.

The ranking of the alternative technologies is first carried out at the actual level of productivity followed by the manufacturer's recommended or expected productivity level.

Table 32 shows that, at 15% discount rate, the U.K. composite unit has the highest capital cost per job, followed by Japanese. The capital cost/unit of labour of U.K. and the Japanese alternatives are about 36.7% and 7.8% higher than the least-cost technology. The difference in K/L cost of least-cost and the second-best (Romanian) composite alternatives is insignificant (about 0.3%). Alternatives ranking from V to XII require a substantially lower capital cost/unit of labour than their modern alternatives. The RFC power-loom composite option (rank VI) which has the highest K/L cost in this group, still requires only 15.40% of the K/L cost of the least-cost technology. Similarly, the technology that requires the lowest capital per employee (rank X) has only 3.60% the K/L cost of the least-cost technology.

The difference of PVCs between least-cost (Indian) and the second-best (Romanian) and the Japanese is not significant, (1.39% and 2.67% respectively). The difference between U.K. and Indian technology is 10.11%.

The alternatives that combine least-cost spinning, service centre and pit-loom (rank V) and the RFC composite unit with power-loom (rank VI) have PVCs of BDT 980.90 million and BDT 1001.88 million respectively. The difference in PVC between these alternatives and the least-cost is 16.92% and 19.42% respectively. The PVC in excess of the least-cost compared to alternatives ranking VII (least-cost spinning and pit-loom) and VIII (least-cost spinning and CR-loom) increases further by 24.15% and 26.76% respectively. The combined pit-loom is, therefore, marginally more efficient (2.6%) than the CR-loom. The PVC of alternatives ranking between IX and XII is between 34.5% and 89.8% higher than the least-cost.

Calculation of NPVs, based on selling price of BTMC grey cloth, shows that the efficiency of the modern technologies has increased more significantly as composite units than as spinning units. At a 15% discount rate, for example, all modern spinning alternatives had negative NPVs, whereas all the modern composite technologies generate surplus.

The least-cost spinning, service centre and pit-loom (rank V) is the only combined alternative that generates a surplus. Its NPV is low compared to that of the least-cost composite unit. The RFC composite unit with power-loom (rank VI) becomes marginally inefficient. The least-cost spinning and pit-loom (rank VII), which is the second most attractive option for employment expansion, has negative NPV. This option would, therefore, require 5.5 times more subsidy (as discussed below) per job than the RFC power-loom composite unit (rank VI). It follows that the least-cost spinning and CR-loom (rank VIII) and alternatives with RFC, ATDA pedal and KVIC hand spinning, when combined with the pit-loom (i.e. technology ranks X, XI and XII), have higher negative NPVs. Although these technologies offer a high level of employment expansion, there has been a substantial increase in their requirement for subsidy.

PVC/unit cost of the second-best and the Japanese technologies is 1.41% and 2.65% respectively higher than the least-cost. Unit cost for the U.K. technology increases further by 10.07% because of its higher investment and operating costs. For combined composite technologies, ranking between V and XI, although unit cost is higher than of the modern composite, it remains within 50% more than that of the least-cost technology. But for the KVIC hand spinning and pit-loom (rank XII), the unit cost has increased to almost twice than that of the least-cost.

The technology option at present promoted by the textile policy of Bangladesh is the combination of modern spinning and traditional weaving. It emerges that such a combination is highly inefficient. Handloom weaving, however, can increase its acceptability as an option if traditional preparatory operations are performed at the service centre (rank V). The overall conclusion emerges from the table that handloom weaving appears to be a better option when combined with modern, rather than intermediate spinning. Among RFC composite units, power-loom (rank VI) has 18% less PVC than the pedal-loom (rank XI); however, both composite options are highly inefficient compared to the least-cost option (Indian).

The analysis, thus far, has assumed the yarn price as fixed by the government. It would be convenient here to use yarn price at the cost of production, to remove subsidy, and reevaluate alternatives that use yarn as input. This shows that PVCs of these technologies increase between about 4% and 23.8%, compared to the least-cost composite technology; hence, the alternatives become less efficient.

The least-cost (rank I) composite technology creates an employment of 1697, while the KVIC hand spinning and pit-loom (rank XII) generates 56 884. Thus the least-cost creates only 2.98% of the employment that the most labour-intensive alternative does in order to produce 31 million m^2 of cloth. Among the modern composite units, the differential in employment generation is less significant than for the combined alternatives. The second-best (rank II) technology provides the highest employment of 1735, while the U.K. technology creates the lowest of 1599. The employment level of alternatives V to XI varies between 9 750 and 34 194. Therefore, any of these alternatives will at least provide a minimum of 5.75 times and a maximum of 20.15 times the employment of the least-cost technology.

The trade-off between economic efficiency and employment of the alternatives is calculated from the increase in PVCs and employment in excess of the least-cost technology. The table shows that if the expansion of employment is the objective, then the Japanese and the U.K. options would be rendered inefficient, as their increase in PVCs does not correspond with the increase in employment. The possibility of trade-off would, therefore, be examined for the modern technologies that rank I and II and the combined alternatives from V to XII.

The second-best (Romanian) composite technology could be examined for its acceptability. It has PVC in excess of minimum of BDT 11.66 million, which is the lowest among all the other alternatives, and is only about 1.39% of the PVC of the least-cost option; its initial investment cost is only 2.63% higher. The additional employment offered by the second-best technology is only 38 which appears to be a marginal contribution to employment expansion. The employment elasticity of PVC is 1.62 which indicates only 1% increase in PVC and 1.62% for employment. It is not a favourable trade-off; therefore, the second-best option does not appear to be an attractive alternative to the least-cost technology for employment expansion.

Among the combined alternatives, the least-cost spinning, service centre and pit-loom composite alternative (rank V) provides the most attractive option for employment expansion. It requires the lowest cost of BDT 8260, while the second-best has the highest BDT of 306 840 to create an additional job compared to the least-cost technology. The remaining alternatives, ranking between VII to X and XII, require between 16% and 54% excess cost per employment compared to the least-cost technology. RFC composite alternatives appear to be highly inefficient choices for employment expansion, as pedal- and power-loom composite options require about 2.45 and 2.85 times excess cost per additional job. The least-cost spinning and pit-loom (rank VII) is the option favoured by the present textile policy of Bangladesh. Therefore, this option and the option that combines the least-cost spinning, service centre and pit-loom (rank V) are further examined for employment expansion. The cost per additional job for technology VII is about 16% higher than for technology V. The option V not only has the lowest cost per additional job but also has the least PVC among all the combined technologies. The policy of the government, therefore, has been a deliberate attempt to sustain employment in the handloom sector. It is worth noting that the efficiency of option VII can be substantially increased if the traditional preparatory weaving is replaced by the service centre.

The employment elasticities of combined alternatives (ranks from V to XII) vary between 24.46 and 59.93. Technology ranks V and VII, which are of interest here, have employment elasticities of 59.93 and 51.73 respectively. Therefore, among the combined composite units, technology V, with the lowest cost per additional job, has also a higher employment elasticity. This makes it the most attractive option, with an employment expansion possibility of 17 189 -- 10.13 times higher than the least-cost technology. The least-cost spinning and pit-loom (rank VII), which has the second highest employment elasticity, provides additional employment of 21 155 -- about 12.47% times higher than the least-cost and about 23.07% higher than the most attractive option (rank V), requiring 8.2% less investment. However, as technology ranking V has 6% less PVC than the alternative VII, it, therefore, emerges as the most attractive option on efficiency grounds and in trade-off between expansion of employment and efficiency.

The present textile policy, which advocates a freeze in the capacity of auto or power-looms in the cotton-textile sector while maintaining expansion of the spinning capacity to supply handloom weavers, has economic costs, irrespective of the source of the spinning alternatives. Even with the most efficient spinning alternative (Indian), such a policy would cause a loss in NPV of BDT 9600 for each additional job created, compared to the least-cost technology, of which BDT 1980 would have to come from other sectors of the economy. Economic surplus is essential for economic growth; therefore the present textile policy, which subsidizes yarn, is not well grounded. The burden of the policy could be alleviated if traditional preparatory weaving were replaced by the service centre. This would eliminate at least BDT 41.96 million in subsidy. It needs to be added here that this change would yield improved quality, but technological improvement on the existing pit-looms would be necessary (Jain, 1983, pp. 1517-1526).

<u>PVC, NPV, PVC/Unit at expected productivity levels of the alternative composite technologies</u>

Evaluation of the alternative composite technologies at expected or manufacturers' recommended levels indicates that improvement in efficiency can be achieved. An increase in productivity reduces the unit cost and thereby increases profitability. The possible productivity gain can only be attained for the modern and the intermediate composite alternatives, while the productivity level of the traditional technologies remains unchanged as it is based on actual observation.

Table 32 shows that, at 15% discount rate, the ranking of most composite alternatives remain unchanged. The Indian composite alternative remains the least-cost technology, and its PVC decreases by 1.92%. Similarly, the PVCs of second-best (Romanian), Japanese and U.K. alternatives decrease. Among the modern alternatives, the Japanese has the lowest decrease in PVC; therefore, the productivity gain that could be achieved is relatively low because the actual productively level attained for this technology is higher than that of other modern alternatives (chapter four). The PVC in excess of the least-cost and the second-best technologies increases by BDT 1.51 million from the actual level, which means that the second-best would then require an increase of 12.95% in cost to create an additional job compared to the least-cost.

For combined composite alternatives ranking between V and IX, the PVCs of the least-cost spinning, service centre and pit-loom (rank V), RFC power-loom (rank VI) and the least-cost spinning and pit-loom (rank VII) decrease by 1.0, 1.65 and 0.96% respectively. However, the cost per additional job would increase by 4.5% and 2.9% for alternatives ranking VI and VII, while, it would decrease marginally (by 0.2%) for alternative V. The least-cost spinning and CR-loom (rank VIII) and the RFC power spinning and pit-loom (rank IX) have only marginal efficiency gains available; their PVCs decline by 0.93 and 1.90% respectively from the actual productivity level.

The NPVs of least-cost and the second-best composite technologies increase by BDT 16.15 million and BDT 14.31 million respectively from the actual to expected productivity level. Similarly, the NPVs of the Japanese and the U.K. alternatives have increases by BDT 13.06 million and BDT 13.86 million respectively. Among the modern alternatives the least-cost has the highest increase in NPV.

Among the combined alternatives, NPV at the expected productivity level for alternative V increases by BDT 9.77 million, while the RFC power-loom composite unit recovers from a net loss of BDT 2.89 million to a surplus of BDT 13.63 million, i.e. a net gain of BDT 16.52 million, which is marginally higher than the least-cost technology. The least-cost spinning and pit-loom (rank VIII), on the other hand, remains inefficient but reduces its loss in NPV by BDT 10.06 million. Although the loss in NPVs of alternatives of ranks VIII to X decreases, they remain highly inefficient.

The difference in PVC/unit cost between the least-cost and the second-best increases marginally from 1.77% to 1.80%, while for the Japanese and the U.K. technologies it increases from 2.65% to 3.15% and 9.73% to 10.63% respectively from the actual to expected productivity level. For combined alternatives, the unit-cost differential of almost all these alternatives also increases compared to the least-cost.

It is evident, therefore, that the selection and ranking of the alternatives are invariant at the expected, or higher, productivity level. The least-cost Indian technology emerges as the best option despite its low productivity, because of its low investment cost among the modern alternatives. The efficiencies of combined alternatives can be increased, if modern and intermediate spinning operate efficiently, thereby reducing the input cost of the traditional sector.

<u>Sensitivity analysis of selective composite technologies using efficiency prices</u>

In this section the ranking of the alternative technologies is re-appraised in the light of sensitivity analysis. It is already established that the least-cost Indian modern composite technology is more efficient than other modern and combined alternatives. Therefore, the re-appraisal concerns selective composite technologies. In the modern sector, these are the least-cost and the second-best (Romanian); from the combined alternatives, the options established as attractive for employment expansion are least-cost spinning, service centre, and pit-loom (rank V), RFC power-loom composite technology (rank VI) and least-cost spinning and pit loom (rank VII). These alternatives are evaluated using efficiency prices. The prices adjusted are those of capital and labour.

The capital or the investment cost has been adjusted for its foreign exchange component, which covers imported machinery and equipment. Construction and other costs are stated in local currency. Therefore, the investment costs to be adjusted are those for modern and intermediate technologies with the exception of power-loom and the traditional handlooms, which contain entirely of domestic costs. The conversion of the foreign exchange rate has earlier been made at the official rate. It is essential to ascertain the effectiveness of this rate while estimating the opportunity cost of the foreign exchange component of the investment. This has been done by calculating the shadow exchange rate (SER) using the formula taken from the UNIDO guide to practical project appraisal (UNIDO, 1978, p.48) and also the information given in the table for input-output analysis of Bangladesh (Bangladesh, 1980 c, pp. 27-29). The shadow exchange rate calculated shows that the cost of foreign exchange has been undervalued by about 20%.

For a new investment, the price-efficiency appraisal usually estimates the opportunity cost of labour on the assumption that the labour would be drawn from other sectors of the economy. In developing countries, any surplus labour is assumed to be employed in the agriculture sector; therefore, the labour required for the investment would be drawn from that sector. The opportunity cost of a certain amount of labour is ideally the loss in output due to the withdrawal of that quantity of labour. The expansion of either modern or the intermediate spinning would draw labour from the agriculture sector. However, it could be argued that the expansion of modern or RFC power-loom weaving could result in loss of production in the handloom sector. Therefore, the opportunity cost of labour for spinning and weaving may not be the same. The daily wages of handloom weavers have been found to be BDT 13.06 and BDT 16.98 for pit- and the CR-looms respectively. As pit-loom is established as the most efficient among the handlooms, the daily wage rate of its weavers is a matter of interest here. The pit-loom wage rate is about 68% that of unskilled labour in the modern sector and 80% of that in the intermediate sector. However, the calculation of the opportunity cost or the efficiency wage of unskilled labour if drawn from the agriculture sector poses certain problems. But estimates made in a related textile study to ascertain the economic wage rate of unskilled labour would be of use here (NEI, 1980, pp. 87 and A.14). According to this study the economic wage rate of 1981 has been estimated to be BDT 10.56 per day. Therefore, the economic wage rate of unskilled labour is about 81% of the pit-loom weaving, equivalent to 65% and 55% of wage rates in the intermediate and modern sector respectively. It is assumed that the daily wage rate of the pit-loom represents the opportunity cost of labour for the weaving sector, while for spinning, the economic wage rate calculated is used for modern and the intermediate technologies. Therefore, for efficiency analysis, the adjustment in wages is made by factors 0.55 and 0.68 for modern spinning and weaving and for the intermediate by factors 0.65 and 0.8 respectively. For the combined composite unit, no adjustment is required for pit loom wages; the actual wages found are used.

<u>Ranking of selective composite alternatives according to efficiency pricing of the factor-inputs</u>

Table 33 shows the ranking of the selected alternative composite technologies following the adjustment of factor prices. It has been seen that although the efficiency of the individual technology increases at the expected productivity level, the ranking remains unaffected. Therefore, re-appraisal at actual productivity level alone would examine the sensitivity ranking of the alternatives.

It appears from the table that the ranking of least-cost and the second-best technologies remains unchanged. However, among the combined alternatives, the RFC composite unit with power-loom (previously ranked VI) emerges as more efficient than the least-cost spinning, service centre and pit-loom (previously ranked V). But the ranking of the least-cost spinning and pit-loom remains unchanged.

Therefore, the adjustment of factor prices does not change the relative superiority of the modern sector, i.e. the least-cost and the second-best continue to be the preferred alternatives when economic efficiency is the objective of the choice. Yet, for employment expansion, the intermediate (RFC) composite unit appears to be an attractive option having a comparative advantage in its use of local power-loom machinery and large savings in its wage bill by using economic wage rates.

<u>PVC, NPV, PVC/unit of selected composite technologies</u>

Table 33 shows that use of efficiency rather than market prices of factor inputs increase the PVCs of least-cost and the second-best technologies by 1.69% and 1.75 % respectively. The PVC of RFC composite unit with power-loom decreases by 5.22%; for the least-cost spinning, service centre and pit-loom (previously ranked V) and the least-cost spinning and pit-loom (previously ranked VII), it increases marginally by about 0.36% and 0.2% respectively. The difference in PVC between the least-cost and the second-best technologies remains almost unchanged. For RFC power-loom composite unit, the differential decreases from 19.42% to 11.30%, and for alternatives ranking V and VII these differentials decrease marginally from 16.92% to 15.40% and from 24.15% to 22.33% respectively. Therefore, the only notable change in PVC has taken place for RFC composite unit, but it is not significant enough to change the relative superiority of the least-cost (Indian) technology.

At efficiency prices, the NPVs of least-cost and second-best technologies decrease by 9% and 10% respectively. The NPV of RFC power-loom composite unit increases from a loss of BDT 2.89 million to a net surplus of BDT 49.44 million, and, for least-cost spinning, service centre and pit-loom (rank VI) technology, its surplus declines by about 19%. For least-cost spinning and pit-loom (rank VII) technology, the loss in NPV increases by 5%. Therefore, the loss in NPV per additional job for the RFC power-loom composite alternative compared to that of the least-cost technology declines from BDT 20 120 to 12 120 at market prices. It is a substantial decrease in cost for the creation of an additional job, yet is 46% higher than the least-cost spinning, service centre and pit-loom. Although the RFC composite technology no longer requires any subsidy for an additional job, it would still incur a cost in loss in surplus compared to the least-cost.

Finally, the PVC/unit for selected composite technologies is examined. Although at efficiency prices the unit cost of the least-cost technology increases, it remains the lowest among all the alternatives. The unit costs of least-cost and second-best technologies increase by 1.68% and 1.74% respectively compared to their market prices. The PVC/unit of RFC composite unit with power-loom, however, decreases by 5.18%, and, for least-cost spinning, service centre and pit-loom and least-cost spinning and pit-loom, the unit costs have marginal decreases of about 0.4% and 0.2% respectively. The unit-cost differential of the least-cost technology compared to the second-best remains almost unchanged, but for technology ranks V and VII, it increases marginally by 2.4% and 1.8% respectively. On the other hand, the unit-cost differential of the RFC power-loom composite unit decreases by 8.06%. This relative decline in unit cost is substantial, yet the unit cost of the least-cost technology is about 18.25% less.

It is worth mentioning that the adjustment in capital and labour costs made here is not a very detailed one. A detailed efficiency pricing analysis would require exclusion of all taxes, duties and subsidies along with adjustment of all imported components of the investment and operating costs with the economic exchange rate. However, such an exercise has not been undertaken here, as the least-cost and the second-best technologies are highly efficient compared to their alternatives. It appears rather, from the preliminary calculation, that exclusion of duties and taxes and adjustment of foreign exchange make the least-cost and second-best technologies relatively more attractive than their alternatives. The other important feature that deserves special attention is the improvement in efficiency of the RFC composite unit over the combined least-cost spinning, service centre and pit-loom. The former technology generates about 52% the employment the latter generates, requiring an additional investment cost of 6.42 %. However it provides a surplus of BDT 33.6 million higher than the least-cost spinning, service centre and pit loom technology. Therefore, at efficiency prices of factor inputs, the RFC composite unit with power-loom appears to be an attractive option if employment expansion is not the objective. Compared with the least-cost technology, the RFC composite unit will have a loss in NPV of BDT 97.57 million, but has 5.75 times more employment expansion potential.

Chapter Eight

Policy implications of the findings

Important implications can be drawn from the findings, which relate to the present textile policy. First, if the present policy of expansion in spinning capacity is to be continued then the availability of choices from the alternatives is evident. Although intermediate spinning has a substantial employment expansion possibility, it has been proved economically less efficient. Therefore be the planning priorities of Bangladesh and the importance attached to employment expansion will determine whether intermediate spinning should be selected as an option. However, most important, what emerges is that choice exists among modern sources of technology. Substantial economic efficiency could be achieved from the choices available within the modern sources. Furthermore, the combination of individual rather than groups of subprocesses, as selected for this study to form an alternative production technology, could be economically more gainful (Pickett and Robson, 1981, pp. 72-84).

Among the handloom alternatives, pit-loom emerges as more efficient than the CR-loom, but its superiority in economic efficiency is marginal. However, its employment expansion possibility is substantial because of the low capital-cost requirement. But the pit-loom has a higher yarn-breakage rate, and when product quality is an important factor, its marginal superiority may appear not so important. It is worth examining the possibility of making technological improvements to the pit-loom without substantially increasing its cost. This could help increase the efficiency of this loom further and at the same time improve product quality.

The appropriateness of the present textile policy can be reviewed only when the total textile process is examined for a comparable level of output. The policy has advocated technologies combining modern spinning and pit or CR-loom. These technologies, even when combined with the most economically efficient spinning, appear to be inefficient compared to the least-cost (Indian) and the second-best (Romanian) composite options except for their large employment generation potential. The technology options that the textile policy favours and are at present widely in practice are least-cost spinning and pit-loom and least-cost spinning and CR-loom. Additional cost per job to keep these technologies operating on the ground of sustaining employment in the handloom sector are BDT 12 710 and BDT 11 380 compared to the least-cost option. Therefore, the present textile policy of expanding spinning capacity only, while maintaining a freeze on mechanized looms has favoured maintenance of handloom employment at the expense of economic efficiency (Bangladesh, 1988a, p. 20, 69). Such a policy has continuously subsidized the handloom sector at the expense of other sectors of the economy, and has had adverse effects on economic growth.

It can be noted however that transportation and distribution costs for yarn have implications for the efficiency of pit- and CR-looms compared to the modern composite units. If yarn is supplied from intermediate spinning units (RFC and KVIC spinning), located near handloom concentrated areas, than from the modern sector spinning, the efficiency of pit- and CR-looms improves significantly. However, traditional handlooms still remain highly inefficient relative to the modern composite units. If the employment generation objective leads the planners of the country to encourage through policy measures the set up of intermediate technologies, the locations of RFC and KVIC spinning units and service centre would be important. The findings indicate that such units should be located near the handloom concentrated areas.

It has emerged that traditional preparatory weaving processes are highly inefficient. A substantial efficiency gain can be realized if these processes are replaced by the service centre and supply of processed beam to handloom weavers. This technology was found to have generated adequate surplus to be self-supportive and does not require any subsidy from the other sectors of the economy. Also, it has a large potential for employment expansion; therefore the economic cost incurred by the present policy could be minimized if such an option is examined by the economic planners. This option further improves the quality of the product. However, such combined technology requires better organization and management than that prevailing in the handloom sector at present. During the transition of the handloom industry in India, due to competition from the power-loom sector, half the jobs in preparatory weaving were lost between 1974 and 1981 (Jain, 1983, pp. 1517-1526).

This emphasizes the extent of the inefficiency in the traditional preparatory process. Although the service centre is better than the least-cost option in employment expansion, it does not justify consideration when economic efficiency is the criterion of choice among the alternatives. Therefore, the least-cost and the second-best options remain the technologies to choose from.

It emerges that the selling prices of yarn and cloth are not based on a cost-plus concept (IBRD, 1982, p. 111; 1983, p. 65) and that there is excessive government control on product prices, at least for enterprises under public sector (BTMC). The efficiency of alternatives in surplus generation will substantially increase if there is an increase in output prices. Evaluation of alternatives at 1981 Indian output prices, which were about 28% higher, increases surpluses of all modern alternatives significantly and makes a large number of combined alternatives surplus-generating. Therefore, price increases of output would particularly benefit combined alternatives, as most of them are loss-making options. Such an increase in surplus may at least help in discontinuing subsidy. Furthermore, if some of the combined alternatives become self-supportive, it may help the planner to examine these alternatives for efficient trade-offs between employment and economic surplus.

Ultimately, the choice among the alternatives depends on the objectives of the development plans and the priority assigned to employment levels vis a vis economic efficiency. The alternatives that combine modern, intermediate and traditional technologies have no significant savings in capital costs. However, all the machinery and equipment of the least-cost and the second-best technologies are imported, while the preparatory equipment and looms of the traditional technologies are domestically manufactured. For the option in which service centre replaces traditional preparatory weaving, the present technological capability of the country could manufacture the machinery and equipment at present imported from India. At present, only about 28% of the resources for investment are mobilized from domestic savings, and 72% comes from foreign aid (1988). It is imperative to save foreign exchange and reduce the balance-of-trade deficit (which in 1988 was about 73% of the total investment outlay of the country). Because of the low level of income (GDP per capita of BDT 802 in 1988), employment to provide some income has been the priority in all the development plans (1973-90). The problem of employment has been aggravated by the increase in population. It has been observed that the population and the labour force have been growing at the rate of 2.6% and 3.1% respectively (1981). At such a growth rate, the labour force, which comprises 31% of the total population (1985), would increase to 35% and 42% of the total population in 1990 and 2000 respectively (IBRD, 1983, pp. 86-89). The employment problem is, therefore, a growing one. The textile industry, compared to other manufacturing industries, characteristically provides more employment. The required expansion projected for this industry shows (chapter two) employment generation potential sufficient to be commensurate with the government objective of expansion of employment through the manufacturing sector of the economy. The economic planners of the country would have to decide from the alternatives available the expansion policy to be pursued to achieve their development objectives. However, the present study has shown that within the formulated objectives, such as economic growth and expansion of employment, there are choices available in production technology that could help to improve the effectiveness of the policy in generating growth and development.

Glossary of textile terms

Beam	A cylinder (usually of wood or metal) with end bearings, at each end of which may be mounted suitable flanges.
Beaming	The primary operation of warp making in which ends withdrawn from a warping creel, evenly spaced in sheet form, are wound onto a beam of substantial length.
Bobbin	A cylindrical or slightly tapered barrel with or without flange for holding roving or yarns. The term is usually qualified to indicate the purpose or process for which it is used e.g, spinning bobbin and weft bobbin.
Carding	The disentanglement of fibres by working them between two closely spaced, relatively moving surfaces clothed with pointed wires. The process cleans and attenuates a lap of fibres to a rope (sliver) by the combing motion of the carding engine.
Charka	Spinning or roving frames, operated either by hand or pedal to make roving or spin yarn.
Ambar charka	A small ring frame with six spindles in a row in a modern (apron) drafting system. The charka is hand-operated and can spin up to 40s-count cotton yarn.
Pedal spinner	Operated by pedal or treadle, it has 12 spindles. It also has a modern drafting system and can spin cotton yarn up to 50s count.
Combing	Straightening and parallelizing fibres and removing short fibres and impurities by using a comb or combs assisted by brushes, rollers and, sometimes, knives.
Cone	A conical flangeless bobbin on which yarn is wound.
Cone winding	The process which transfers yarn from spinning bobbin to cone to purify the yarn for subsequent processes.
Count	A number indicating the mass per unit length of yarn. For cotton yarn, 840 yards (767.76 m) weighing 1 pound (0.454 kg) is taken as 1 count. The measure of count increases with the fineness of yarn, e.g. 32s count signifies 32 x 840 yards of yarn in 1 pound.
Creel	A structure or frame for mounting supply packages in textiles processing viz. roving, spinning and warping.
Drafting	The process of attenuating laps, slivers and rovings to increase their length per unit by means of rollers rotating at differential speeds.
Drawing	Operation by which carded slivers are blended (or doubled), leveled, and by drafting reduced to the stage of roving. In the cotton section of the textile industry, the term is applied exclusively to processing on one machine, namely, the draw frame.

Drawing-in The process of drawing the threads of the warp through the eyes of the healds and dents of the reed. The operation thus includes that of reeding.

Doffing The operation of removing materials from a machine after processing, for example the full bobbin of yarn from the spinning frame.

End or warp An individual strand (spinning) or an individual warp thread (weaving).

Grey cloth Woven fabrics as they leave the loom, i.e. before any bleaching, dyeing or finishing treatment has been given to it.

Lap In cotton spinning, the sheets of fibre from openers and scutchers are wound on rollers.

Loom A machine for producing cloth by the interlacing of warp and weft threads.

Pit-loom A type of handloom widely used in India and Bangladesh. The loom is permanently built on the floor over a pit 30 to 60 cm in depth. All motions, i.e shedding, picking and beating-in, are done manually.

CR-loom Another type of handloom widely in use. Compared to the pit-**(semi-auto)** loom, it is well built with mechanical attachments for controlling warp and weavers' beam. The weaving method is almost identical to that of pit-loom.

Pedal-loom Another type of handloom, which has almost the same features as the CR-loom but is better designed.The shedding motion is controlled by the right and left pedals, while picking and beating-in are done manually.

Power-loom Rarely used in modern cloth manufacturing. however, it is still widely used in developing countries, both in factories and small-unit production. All motions, i.e shedding, picking and beating-in, are power-operated. However, shuttle change is done manually.

Automatic-loom This operates at high speed and all operations viz. let-off and loomtake-off are automatic. The shuttle is also automatic, which increases loom production.

Openingand cleaning (Blow -room) The action of separating closely packed fibres from each other an early stage in the theprocessing of raw material into yarn.

Picks or weft A single weft thread placed between warp threads in one passage of the shuttle through the other.

Pirn A wood, paper, metal or plastic support, slightly tapered, with or without a conical base on which yarn is wound for use as weft.

Pirn Winding The process by which the yarn is wound to make full pirn bobbin.

Reed A device consisting of several wires closely set between two baulks to separate the warp threads, determining the spacing of the warp threads, guiding the shuttle and beating-up the weft.

Roving A name given, individually or collectively, to the relatively fine fibrous strands used in the later or final processes of preparation for spinning. The machine used to make roving is known as a roving or speed frame.

Scutching An operation in which cotton is mechanically opened and cleaned into a loose, open condition for spinning. The opened and cleaned cotton forms a continuous lap or web of cotton on a rod to be fed in the carding process.

Scutcher The end section of the series of opening and cleaning machinery, which finally assembles the opened and cleaned fibres into laps.

Selvedge This term refers to the longitudinal edges of fabric that are found during weaving, with weft not only turning at the edges but also passing continuously across the width of the fabric from edge to edge.

Shuttle A yarn package carrier that is passed through the shed to insert weft during weaving, across the loom. It is made from wood pointed at both ends and tipped with steel. It is hollowed out in the centre and provided with a hinged metal tongue. The pirn is present upon this and the weft can be drawn out through an eye in the front of the shuttle.

Spindle A mechanism for spinning yarn, usually ring spinning, and consisting of delivery rollers, a tapered length of steel that can be rotated at high speed and a ring and traveller for inserting twist and winding the yarn onto a bobbin.

Spinning The process that delivers a continuous thread from fibres (roving) by twisting them together.

Spinning frame A number of spindles assembled together into a frame, known as spinning frame. The frame may contain between 6 and 500 spindles. The Ambar, hand and pedal spinning, for example, have 6, 6 and 12 spindles respectively, while the intermediate power spinning could have 48 spindles. The modern spinning frame contains between 400 and 500 spindles.

Sizing The method of mechanical sizing in which a warp is transferred from warp beam to loom beam. During the transfer a mixture of starch materials is added to reduce hairiness and friction of warp yarns.

Traveler The metal or plastic component through which the yarn passes on its way from the ballooning eye to the package surface in ring spinning. It is mounted on the ring and is dragged around by the yarn.

Warping To arrange threads in long lengths parallel to one another thus preparing for further processing, i.e. beaming.

Weaving To form a fabric by interlacing warp and weft with the help of shuttles.

Yarn An assembly of substantial length and relatively small cross- section of fibres with twist produced by spinning frames.

Table 1. Gross Domestic Product, per-capita income, foreign trade, investment and savings of Bangladesh, 1970-88 (000 000 BDT).

Item	1970-71	71-72	72-73	73-74	74-75	75-76	76-77	77-78
GDP[a]	48 993	42 147	45 300	48 910	50 630	55 480	56 370	60 240
Population (000 000)	72.3	72.4	74.0	76.4	78.0	79.9	81.8	83.7
Per-capita income (BDT)	677	582	612	640	649	694	689	719
Annual growth rate(%)								
GDP	(5.5)	(14.0)	7.5	8.0	3.5	9.6	1.6	6.9
Per-capita income	(12.0)	(14.0)	5.1	0.5	1.4	6.9	(0.7)	4.4
Balance of trade[b]								
Export	1 251	N/A	N/A	2 974	3 061	5 517	6 255	7 406
Import	1 570	N/A	N/A	7 320	10 842	14 703	13 993	18 216
Balance	(319)	-	-	(4 346)	(7 781)	(9 186)	(7 738)	(10 810)
Investment[b]								
Public investment	-	-	2 578	2 326	3 703	4 841	6 790	8 670
Private investment	-	-	1 449	1 685	3 185	3 915	4 413	5 948
Total	-	-	4027	4 011	6 888	8 756	11 203	14 618
Financing of investment (%)								
Foreign aid	N/A	N/A	98.40	93.6	108.2	124.63	64.69	78.29
Domestic savings	N/A	N/A	1.60	6.4	(8.2)	(24.63)	35.31	21.71
Total investment as % of GDP	-	-	8.9	8.2	13.6	15.78	20.23	24.27
Savings as % of GDP	-	-	0.1	0.4	(0.4)	(2.01)	(3.75)	2.44

Table 1 contd.

Item	1978-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88
GDP[a]	62 810	63 590	67 510	68 460	70 820	73 800	76 680	80 030	83 160	85 550
Population (000 000)	85.6	87.7	89.6	92.1	94.4	96.8	99.2	101.7	104.1	106.6
Per-capita income (BDT)	734	725	754	743	750	762	773	786	798	802
Annual growth rate(%)										
GDP	4.3	1.2	6.2	1.4	3.4	4.2	3.9	4.4	3.9	2.9
Per-capita income	1.9	(1.2)	4.0	(1.4)	0.9	1.6	1.3	1.8	1.5	0.5
Balance of trade[b]										
Export	9 282	11 241	11 599	12 555	16 162	19 902	24 155	24 314	32 630	38 081
Import	23 343	36 760	41 390	51 550	54 889	58 433	68 770	70 650	80 261	93 470
Balance	(14 061)	(25 519)	(29 791)	(38 995)	(38 727)	(38 531)	(44 615)	(46 336)	(47 631)	(55 389)
Investment[b]										
Public investment	9 296	13 493	15 130	16 308	18 031	19 467	22 100	28 383	36 299	44 804
Private investment	7 247	8 797	22 102	23 529	21 181	23 614	29 912	29 299	33 264	31 092
Total	16 542	22 290	37 232	39 837	39 212	43 081	52 012	57 682	69 563	75 896
Financing of investment (%)										
Foreign aid	86.04	74.98	79.85	97.44	97.75	90.26	81.76	75.34	71.73	71.83
Domestic savings	13.95	25.02	20.15	2.56	2.25	9.74	18.24	24.66	28.27	28.17
Total investment as % of GDP	26.34	35.05	48.66	58.19	55.37	58.38	67.83	72.08	83.65	88.72
Savings as % of GDP	1.59	3.23	3.22	0.38	0.31	1.20	2.33	3.05	3.66	3.63

Notes: [a] 1972-73 constant prices
[b] Current prices

Sources: Bangladesh (1981a, 1982a, 1987 ,1989a), Statistical year book of Bangladesh (investment and domestic savings).
Bangladesh (1988b), Bangladesh economic survey.

Table 2. Cotton manufacturing facilities, Pakistan 1947-71.

Period	Years	East Pakistan No. of spindles (000)	East Pakistan Annual growth (%)	West Pakistan No. of spindles (000)	West Pakistan Annual growth (%)	All Pakistan No. of spindles (000)	All Pakistan Annual growth (%)	East Pakistan No. of looms (000)	East Pakistan Annual growth (%)	West Pakistan No. of looms (000)	West Pakistan Annual growth (%)	All Pakistan No. of looms (000)	All Pakistan Annual growth (%)
At partition	1947-48	99	-	78	-	177	-	2.58	-	2.22	-	4.8	-
Preplanning period	1948-55	285	26.9	1 281	220.2	1 566	112.1	3.26	3.7	19.74	112.9	23.0	54.2
First 5-year plan	1955-60	323	2.6	1 618	5.3	1 941	4.8	3.26	0	26.74	7.1	30.0	6.1
Second 5-year plan	1960-65	617	18.2	1 967	4.3	2 584	6.6	5.00	10.6	31.00	3.2	30.0	5.2
Third 5-year plan	1965-70	750	4.3	2 600	6.4	3 350	6.0	7.00	8.0	30.00	(0.64)	37.0	0.6
Bangladesh	1971-72	750	-	-	-	-	-	7.00	-	-	-	-	-

Sources: Bangladesh (1980d), Ahmed (1969).

Table 3. Comparative value-added of textile industry at current prices.

Item	1972-73	73-74	74-75	75-76	76-77	77-78	78-79
Value added (BDT 000 000)							
Manufacturing	3 090.9	3 863.1	4 349.6	5 121.6	6 929.4	8 103.0	10 263.0
Cotton Textiles							
Public and private mills	474.36	620.87	564.54	605.29	391.54	729.89	794.20
Other Textiles	104.48	20.81	24.38	21.39	98.52	152.91	127.73
Handloom	83.04	80.68	79.17	61.32	21.45	58.82	63.32
Total	661.88	722.35	668.09	688.00	511.51	941.62	984.25
As % of value added of manufacturing	21.41	18.70	15.35	13.43	7.38	11.61	9.60
Growth rate (%)							
Manufacturing	-	18.11	12.59	17.75	35.30	16.94	26.65
Public and private mills	-	30.89	(9.07)	7.21	(35.31)	86.41	8.81
Handloom	-	(2.85)	(1.86)	(22.55)	(65.02)	174.21	7.65
Employment (000)							
Manufacturing	182.09	337.35	370.09	373.93	362.10	394.32	400.67
Public and private mills	55.78	66.42	67.78	65.06	62.19	67.62	75.82
Employment of mills as % of manufacturing	-	19.69	20.10	17.40	17.18	17.15	18.92
Value added per employee							
Manufacturing (BDT 000)	16.97	11.45	11.75	13.70	19.14	20.55	25.61
Public and private mills (BDT 000)	8.50	9.35	8.33	9.30	6.30	10.79	10.47

Table 3 contd.

Item	1979-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88
Value added (BDT 000 000)									
Manufacturing	13 061.0	14 291.0	15 711	19 232	20 070	23 956.0	29 567.17	31 954.3	41 010
Cotton textiles									
Public & private mills	994.44	1 030.21	969.57	1 371.93	1 512.14	1 802.24	3 497.12	2 730.58	3 485.85
Other Textiles	189.64	218.07	255.13	319.99	320.35	389.57	453.48	604.82	680.77
Handloom	124.93	100.17	130.43	186.70	227.95	200.88	417.43	398.09	459.31
Total	1 309.01	1 348.45	1 355.12	1 878.62	2 042.44	2 392.69	4 368.03	3 733.49	4 625.93
As % of value added of manufacturing	10.02	9.54	8.62	9.77	10.17	9.99	14.77	11.68	11.28
Growth Rate(%)									
Manufacturing	27.26	8.17	11.20	22.41	4.36	19.36	23.42	8.07	28.34
Public and private mills	25.21	3.60	(5.89)	41.50	26.84	3.57	94.04	(21.92)	27.66
Handloom	97.30	(19.82)	30.21	43.14	22.09	(11.88)	107.80	(4.63)	15.38
Employment (000)									
Manufacturing	417.26	438.04	456.29	470.67	485.98	468.61	447.25	467.15	497.36
Public and private mills	76.99	74.96	77.07	80.92	84.97	60.07	68.35	68.43	67.00
Employment of mills as a % of manufacturing	18.45	17.11	16.89	17.19	17.48	12.81	14.32	14.65	13.47
Value added per employee									
Manufacturing (BDT 000)	31.30	32.26	34.43	40.86	41.30	51.12	66.11	68.40	82.46
Public and private mills (BDT 000)	12.92	13.74	12.58	16.95	17.79	30.00	51.16	39.90	52.03

Sources: Bangladesh (1973-1989, 1981a, 1982a, 1985a, 1989a), BTMC (1974-89), BTMA (1984-89).

Table 4. Operational performance of spinning and weaving mills.

	1969-70	72-73	73-74	74-75	75-76	76-77	77-78	78-79
Spinning								
Capacity utilization								
Total installed spindles(000)	750.00	835.09	858.12	889.57	905.53	921.30	976.83	972.16
Av. running spindles(000)	660.00	626.94	656.64	692.26	659.84	685.23	798.72	793.56
Utilization (%)	88.00	75.07	76.52	77.82	72.87	74.37	81.76	81.63
Operational performance								
Converted prodn.(000 000 Kg)[a]	48.38	36.27	43.32	45.61	41.32	42.37	48.49	48.24
Spindle production/shift (g)	81.44	64.29	73.30	73.21	69.58	68.70	67.46	67.54
Weaving								
Capacity utilization								
Total installed looms	7 000	6 800	7 375	7 563	7 636	7 859	7 986	7 458
Av. running looms	3 000	3 300	4 315	4 972	4 847	4 531	5 379	5 600
Utilization (%)	42.85	48.97	58.62	63.62	63.47	57.65	67.35	74.72
Operational performance								
Converted production (000 000 m^2)[b]	N/A	53.42	71.95	78.55	69.45	62.75	77.30	80.72
Loom production/shift (m^2)	23.90	17.99	18.53	17.55	15.92	15.39	15.97	16.02
Growth rate (%)								
Spindles	3.65[c]	11.35	2.75	3.66	1.79	1.74	6.03	(.48)
Looms	(1.0)[c]	(2.86)	8.48	2.55	.97	2.92	1.62	(6.61)
Spindle:loom ratio	107:1	123:1	116:1	118:1	119:1	117:1	122:1	124:1

Table 4 (contd.)

	1979-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88
Spinning									
Capacity utilization									
Total installed spindles (000)	1 031.56	1 057.46	1 032.238	1 019.942	1 015.00	1 104.00	1 202.13	1 247.15	1 273.52
Av running spindles (000)	821.30	863.11	784.500	846.552	816.67	874.13	849.42	980.27	1004.23
Utilization (%)	79.62	81.62	76	83	80.46	79.17	70.64	78.60	78.85
Operational performance									
Converted prodn. (000 000 Kg)[a]	50.97	55.23	48.63	50.90	50.98	56.16	52.48	60.05	57.88
Spindle production/shift (g)	68.96	71.10	68.88	66.81	69.36	71.39	68.65	68.07	64.04
Weaving									
Capacity utilization									
Total installed looms	7 458	7 592	6 848	6 848	5 690	5 980	6 330	6 310	6 302
Av. running looms	5 458	5 283	4 520	4 520	4 182	4 630	4 016	4 169	3 868
Utilization (%)	72.73	69.59	66	66	73.50	77.42	63.44	66.07	61.38
Operational performance									
Converted production (000 000 m^2)[b]	84.52	71.71	69.70	71.16	60.41	69.10	60.15	62.79	65.77
Loom production/shift (m^2)	17.21	15.08	17.13	17.49	16.05	16.58	16.64	16.73	18.89
Growth rate (%)									
Spindles	6.11	2.51	(2.39)	(1.19)	(.48)	8.77	8.90	3.73	2.11
Looms	-	1.80	(9.80)	-	(16.91)	5.10	5.85	(.32)	(.13)
Spindle:loom ratio	138:1	139:1	151:1	149:1	178:1	185:1	190:1	198:1	202:1

Notes: [a] Figures are converted to uniform equivalent of 32s yarn.
[b] Figures are converted to uniform equivalent of medium cloth (21.3 warp/cm and 21.3 weft/cm).
[c] Compound annual growth rate 1969-70 to 1972-73.

Sources: BTMC (1973-74 to 1987-88), Annual Reports.
BTMA (1984 to 1989), Annual Reports.

Table 5. Employment and productivity in the Bangladesh cotton and textile industry.

	1972-73	73-74	74-75	75-76	76-77	77-78
Employment						
Officers and staff	7 156	8 647	9 562	9 635	9 637	11 114
Production workers	48 620	57 771	58 219	55 426	52 557	56 504
Total	55 776	66 418	67 781	65 061	62 194	67 618
Spindles/employee						
No. of spindles	835 092	858 124	889 570	905 532	921 298	976 834
Spindles/production worker	17.17	14.85	15.28	16.33	17.53	17.29
Spindles/all employee	14.97	12.92	13.12	13.92	14.81	14.54
Production worker spindle index (1972-73 = 100)	100	86.50	89.00	95.10	102.10	100.70
All-employee spindle index (1972-73 = 100)	100	86.30	87.64	92.98	98.93	97.13
Productivity						
Total yarn output (000 000 Kg)	36.27	43.32	45.61	41.32	42.37	48.49
Output/production worker (Kg)	746.17	749.80	783.46	745.72	806.10	858.21
Output/all employee (Kg)	650.46	651.82	673.14	635.04	681.31	717.14
Production worker output index (1972-73 = 100)	100	100.50	105.00	100.00	108.03	115.00
All-employee output index (1972-73 = 100)	100	100.20	103.50	97.63	104.74	110.25

Table 5 (contd.)

	1978-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88
Employment										
Officers and staff	11 562	11 664	11 766	12 269	12 049	11 989	9 753	11 566	11 721	11 603
Production workers	64 259	65 329	63 199	64 801	68 871	72 981	50 312	56 783	56 711	55 399
Total	75 821	76 993	74 965	77 070	80 920	84 970	60 065	68 349	68 432	67 002
Spindles/employee										
No. of spindles	972 166	1 031 557	1 057 460	1 032 238	1 019 942	1 015 000	1 104 000	1 202 310	1 247 150	1 273 516
Spindles/production worker	16.73	17.72	18.55	17.66	16.33	13.90	21.94	21.17	21.99	22.99
Spindles/all employee	12.82	13.40	14.10	13.39	12.60	11.95	18.38	17.59	18.22	19.00
Production worker spindle index (1972-73 = 100)	97.44	103.20	108.04	103	95.1	80.96	127.78	123.3	128.0	133.90
All employee spindle index (1972-73 = 100)	85.64	89.51	94.19	89.4	84.16	79.83	122.78	117.5	121.71	126.92
Productivity										
Total yarn output (000 000 Kg)	48.24	50.97	55.23	48.63	50.90	50.98	56.16	52.48	60.05	57.88
Output/production worker (kg)	750.71	780.19	873.86	750.25	739.10	689.09	1 116.15	924.25	1 058.83	1 044.77
Output/all employee (kg)	636.40	662.03	736.65	630.96	629.05	599.92	934.91	767.85	877.48	863.84
Production worker output index (1972-73 = 100)	100.6	104.5	117.11	100.5	99.05	93.56	149.58	123.87	141.90	140.0
All employee output index (1972-73 = 100)	97.84	101.78	113.25	97.00	96.70	92.23	143.73	118.04	134.9	132.80

Sources: BTMC (1973-74 to 1987-88), Annual Reports
BTMA (1984-89), Annual Reports.

Table 6. Product-mix share of the handloom industry (%).

	Sari	Lungi	Gamcha	Chaddar	Others	Total
Dhaka	55.01	23.09	6.45	1.37	14.08	100
Rajshahi	72.43	10.99	9.84	6.74	-	100
Chittagong	4.50	82.94	2.84	3.74	5.98	100
Khulna	28.62	33.62	28.07	1.0	8.69	100
Bangladesh	47.61	31.23	8.77	1.50	10.89	100

Source: Miah (1978).

Table 7. Per-capita consumption, input and output of cotton textiles (1973-88).

Year	Yarn prodn. (000 000 kg)	Yarn imports (000 000 kg)	Total yarn for consumption (000 000 kg)	Handloom production (000 000 m^2)	BTMC & private cloth production (000 000 m^2)	Cloth imports (000 000 m^2)	Total new cloth for consumption (000 000 m^2)	Old cloth imports (000 000 m^2)	Population (000 000)	Per capita consumption new cloth (m^2)	Per capita consumtion old cloth (m^2)
1973-74	43.32	7.26	50.58	372.16	71.95	48.55	492.67		76.4	6.45	
74-75	45.61	4.26	49.88	424.28	78.55	38.86	541.69	86.96	78.0	6.94	1.11
75-76	41.32	4.49	45.81	339.70	69.45	22.49	431.64	124.18	79.9	5.40	1.55
76-77	42.37	3.86	46.22	317.3	62.75	26.70	406.74	204.92	81.8	4.97	2.51
77-78	48.49	13.15	61.64	471.83	77.30	38.04	587.17	252.37	83.7	7.01	3.02
78-79	48.24	5.26	53.50	380.85	80.72	48.46	510.03	245.70	85.6	5.96	2.87
79-80	50.97	5.17	56.14	359.36	84.52	55.05	498.92	214.61	87.7	5.69	2.45
80-81	55.23	8.98	64.21	442.51	71.71	59.07	573.35	325.07	89.9	6.37	3.61
81-82	48.63	10.21	58.84	437.54	69.70	52.12	559.36	338.15	91.9	6.09	3.67
82-83	50.90	13.78	64.92	498.35	71.16	20.30	589.81	319.77	94.3	6.25	3.39
83-84	50.97	13.88	64.86	507.49	60.41	50.47	618.37	161.57	96.8	6.39	1.67
84-85	56.16	29.00	85.16	651.97	69.10	60.99	782.06	286.99	99.2	7.88	2.89
85-86	52.48	29.00	81.49	812.90	60.15	40.97	914.02	516.88	101.7	8.99	5.08
86-87	60.05	32.00	92.05	669.98	62.79	94.00	818.54	178.0	104.1	7.86	1.71
87-88	57.88	31.00	88.88	665.06	65.77	221.01	951.84	102.00	106.6	8.93	0.96

Notes: [a] Total yarn available is assumed to have been consumed by public and private mills and handlooms; cloth for public and private mills is available from BTMC and BTMA; estimated production for handloom is based on cloth production of 10-12 m^2/kg.
[b] Imported cloths includes cotton cloth, polyester blends, nylon, silk etc.

Sources: Bangladesh (1989), communication from the Ministry of Textiles, Government of Bangladesh.

Table 8. Population projections and labour-force growth 1980-2000.

	1980	1985	1990	1995	2000
Population (000 000)	89.6	101.4	113.2	124.2	134.2
Growth rate (%)	2.5	2.2	2.1	1.5	-
Labour force (000 000)	28.7	33.0	38.7	45.3	52.8
Growth rate (%)	3.1[a]	2.8	3.2	3.3	3.1

Note: [a] From 1980 to 2000

Source: IBRD (1980,1983).

Table 9. Wastage level of different technologies(%).

Spinning	Opening and cleaning	Carding	Drawing	Roving	Spinning	Cone winding	Reeling	Bundle press
Modern	5.0	3.0	2.0	2.0	2.0	1.0	0.5	0.5
Intermediate	5.0	3.0	2.0	2.0	2.0	1.0	0.5	0.5
KVIC (Khadi-Ambar)	5.0	3.0	2.0	3.0	3.0	-	0.5	0.5
Intermediate (ATDA Pedal)	5.0	3.0	2.0	3.0	3.0	2.0	-	-

Weaving	Cone-winding	Pirn-winding	Warping	Sizing	reaching-in	Weaving
Modern	1.0	0.5	1.0	1.0	-	Warp 1.0 Weft 0.5
Intermediate (RFC)	1.0	1.0	1.0	1.0	-	Warp 1.0 Weft 1.0
Traditional	2.0	1.5	2.0	1.0	-	Warp 1.0 Weft 1.0
Service centre	1.0	-	1.0	1.0	-	Warp 1.5 Weft 1.0

Sources: Author's survey of 17 mills under Bangladesh Textile Mills Corporation (BTMC), 5 private-sector mills, 214 handloom weaving units, ATDA project in Kusmi Kalan, Uttar Pradesh (UP) and Rural Fabric Centre, Coimbatore, India.

Table 10. Productivity index for surveyed mills (spinning).

		Spindle details			Spindle prodn. (g/shift)					
Sample number	**Vintage**	**Recommended speed (rpm)**	**Lift (cm)**	**Ring dia (cm)**	**At rec. speed**	**Rec. eff. (90%)**	**Actual prodn.**	**RPM at actual**	**PI**	**Actual eff.**
Source: U.K.										
1.	1968	11 000	20.32	4.45	107.44	96.67	87.88	8984	90.9	81.81
2.	1968	11 000	20.32	4.45	107.44	96.67	80.23	8200	83.0	74.70
3.	1970	11 500	20.32	4.45	112.26	100.92	82.21	9130	81.5	73.35
4.	1970	11 500	20.32	4.45	112.26	100.92	93.55	9274	92.7	83.43
5.	1971	11 500	20.32	4.45	112.26	100.92	87.88	8984	87.0	78.3
Average									87.02	
Source: Japan										
6.	1968	11 000	20.32	4.45	107.44	96.67	89.30	9130	92.4	83.16
7.	1968	11 000	20.32	4.45	107.44	96.67	83.55	9565	96.8	87.12
8.	1970	11 500	20.32	4.45	112.26	100.92	84.48	8636	83.7	75.33
9.	1975	12 000	20.32	4.45	117.36	105.46	92.13	9420	87.4	78.66
10	1975	12 000	20.32	4.45	117.36	105.46	96.39	9855	91.4	82.26
11.	1975	12 000	20.32	4.45	117.36	105.46	94.99	9710	90.1	81.09
12.	1975	12 000	20.32	4.45	117.36	105.46	95.25	9740	90.3	81.27
Average									90.3	
Source: India										
13.	1976	12 000	22.86	4.45	117.36	105.46	93.98	9505	88.2	79.38
14.	1976	12 000	22.86	4.45	117.36	105.46	82.63	8550	79.3	71.37
15.	1976	12 000	22.86	4.45	117.36	105.46	94.40	9650	88.7	79.83
16	1976	12 000	22.86	4.45	117.36	105.46	90.72	9275	86.0	77.40
Average									85.55	
Source: Romania										
17.	1976	12 000	22.86	4.45	117.36	105.46	92.13	9420	87.36	78.62

Source: Author's Survey of 17 BTMC mills.

Table 11. Estimated spindle productivity for 1981 machinery (g/shift).

	Spindle details			Expected or recommended					Actual estimated		
Source of machinery	Rated speed (rpm)	Lift (cm)	Ring dia. (cm)	RPM	Prodn. (g)	Eff.(%) (Reff.)	Prodn. (g)	PI	Prodn. (g)	Speed (rpm)	Eff.(%) (Aeff.)
U.K.	16 000	20.32	4.45	13 200	129.13	90	116.09	87.02	101.00	10 325	78.22
Japan	16 000	20.32	4.45	13 000	127.17	90	114.44	90.30	103.33	10 565	81.27
India	16 000	22.86	4.45	13 000	127.17	90	114.44	85.55	97.92	10 454	80.42
Romania	15 000	22.86	4.45	12 900	126.18	90	113.67	87.36	99.31	10 150	78.68

Source: Author's review of technical literature of machinery from sources comprising India, Romania, Japan and U.K.

Table 12. Productivity index for the surveyed mills (weaving) (production in m^2/shift/loom).

		Expected or recommended						
Sample number	Vintage	Picks/min.	Production (m^2)	Reff(%)	Production (m^2)	Actual Prodduction (m^2)	PI	Aeff (%)
Source: Japan								
1.	1962	140	31.62	90	28.46	26.30	92.42	83.18
2.	1964	145	32.74	90	29.47	24.92	84.55	76.10
3.	1964	145	32.74	90	29.47	25.93	88.00	79.20
4.	1964	145	32.74	90	29.47	24.65	83.65	75.28
5.	1964	145	32.74	90	29.47	26.02	88.30	79.47
Average							7.38	78.65

Table 13. Estimated loom productivity for 1981 machine (production in m^2/shift/loom).

	Loom details			Expected or recommended				Estimated actual			
Source	Rated PPM[a]	Width (cm)	Type	PPM	Prodn. (m^2)	Eff. Reff(%)	Prodn. (m^2)	PI	Prodn. (m^2)	(PPM)	Aeff.
U.K.	190	15.24	Battery	170	38.40	90	34.56	87.38	30.19	134	78.65
Japan	160	15.24	Battery	150	33.88	90	30.50	87.38	26.65	118	78.65
India	170	15.24	Battery	180	36.14	90	32.53	87.38	28.42	126	78.65
Romania	170	15.24	Battery	160	36.14	90	32.53	87.38	28.42	126	78.65

Note: [a] PPM: Picks per minute.

Table 14. Production plan (spinning and weaving) (based on manufacturer's recommended production at 32s cotton count).

Source	Machine details	Spinning									Weaving				
		Blowroom (kg)	Carding (kg)	Drawing (kg)	Roving (kg)	Spinning (g)	Cone winding (kg)	Reeling (kg)	Bundle press(kg)	Bailing press(kg)	Cone winding (kg)	Pirn winding (kg)	Warping (kg)	Sizing (kg)	Loom (m^2)
U.K.	Rated capacity	5 189.2	254.0	1 746.4	5.5	129.0	5.9	266.8	725.7	6 805	5.9	6.1	4 536	5 443.2	38.4
	Recommended eff. (%)	80	80	75	90	90	85	80	80	60	85	85	75	70	90
	Expected prodn.(kg/S)[a]	4 150.4	203.2	1 310.9	5.2	11 594.7	5.0	181.4	580.6	4 082.4	5.0	5.2	3 572.1	3 810.2	33.9
	Daily prodn. (3S(kg)[a]	12 451.3	10 973.5	11 793.6	11 036.1	532 819.5	11 580.5	10 886.4	10 450.9	12 247.2	11 580.4	4 871.1	10 714.0	11 430.7	72 786.2
	Daily required prodn(kg)	9 321.5	9 049.3	8 872.4	8 695.5	532 819.5	8 441.5	8 400.6	8 314.5	8 314.6	8 323.5	4 082.4	4 177.6	4 136.8	72 754.2
	No.of M/C or spindles	1L/2S	18	3x2=6	88x8=704	24 960 [b]	110x7=770	20	6	1	110x7=770	26x12=312	1	1	725
	Installed power/M/C(kW)	123	8.4	8	19	18.25	8	1	1.5	15	8	2.5	16	21.95	3
	Total power (kW)	123	151.2	48	152	949	56	20	9	15	56	65	16	21.95	2.175
Japan	Rated capacity	4 472.5	204.1	1 678.3	5.1	127.0	6.1	226.8	725.7	6 804	6.1	5.9	4 263.8	4 862.6	33.8
	Recommended eff. (%)	90	85	80	85	90	85	80	80	60	85	85	75	70	90
	Expected prodn (kg/S)[a]	4 023.4	173.3	1 342.7	4.4	114.5	5.2	181.4	580.6	4 082.4	5.2	5.0	3 197.8	3 402	30.5
	Daily prodn. (3S(kg)[a]	12 074.8	10 410.1	12 083.9	10 033.6	525 307.0	11 235.7	10 886.4	10 450.9	12 247.2	11 235.6	5 053.1	9 593.6	10 206	72 758.8
	Daily required prodn(kg)	9 189.9	8 920.0	8 745.4	8 573.0	525 307.0	8 323.6	8 282.7	8 241.9	8 241.9	8 323.5	4 082.4	4 177.6	4 136.8	72 754.2
	No. of M/C or spindles	1L/2S	20	3x2=6	96x8=768	24 960 [b]	120x6=720	20	6	1	120x6=720	28x12=336	1	1	825
	Installed power/M/C (kW)	100.5	6.6	6.75	15	15	12.5	1	1.5	15	12.5	2.25	15	17.3	3
	Total power (kW)	100.5	132	40.50	120	780	75	20	9	15	75	63	15	17.3	2 475
India	Rated capacity	4 309.2	199.6	1 179.4	4.7	127.0	5.9	226.8	725.7	6 804	5.9	5.4	3 628.8	4 309.2	36.1
	Recommended eff. (%)	85	90	85	85	90	85	80	80	60	85	80	75	70	90
	Expected prodn (kg/S)[a]	3 365.1	179.6	961.3	4.0	114.5	5.0	181.4	580.6	4 082.4	5.0	4.3	2 721.6	3 016.4	32.5
	Daily prodn. (3S(kg)[a]	10 988.5	10 777.5	12 029.5	10 464.6	525 307.0	10 827.4	10 886.4	10 450.9	12 247.2	10 827.4	5 016.8	8 164.8	9 049.3	72 795.4
	Daily required prodn(kg)	9 189.9	8 920.0	8 745.4	8 573.0	525 307.0	8 405.2	8 282.7	8 241.9	8 241.9	8 323.5	4 082.4	4 177.6	4 177.6	72 754.2
	No. of M/C or spindles	1L/2S	20	4x2=8	108x8=864	24 960 [b]	120x6=720	20	6	1	120x6=720	32x12=384	1	1	775
	Installed power/M/C (kW)	90.5	5.6	5.4	13	15	12.4	1	1.5	15	12.4	1.5	13.5	16.5	3
	Total power (kW)	90.5	112	43.2	106	967	74.5	20	9	15	74.4	48	13.5	16.5	2 325
Romania	Rated capacity	4 195.8	177.8	1 156.7	4.7	126.2	5.4	226.8	725.7	6 804	5.9	0.4536	0.4536	0.4536	0.9144
	Recommended eff. (%)	90	90	85	85	90	85	80	80	60	85	100	100	100	100
	Expected prodn (kg/S)[a]	3 792.1	160.1	984.3	4.0	113.7	4.6	181.4	580.6	4 082.4	4.6	0.4536	0.4536	0.4536	0.9144
	Daily prodn. (3S(kg)[a]	11 376.3	10 568.8	11 484.0	10 464.6	525 590.5	10 464.6	10 886.4	10 450.9	12 247.2	10 464.5	5 016.8	8 164.8	9 049.3	72 795.4
	Daily required prodn(kg)	9 194.5	8 924.6	8 749.9	8 577.6	525 590.5	8 328.1	8 285.0	8 241.9	8 241.9	8 328.1	4 082.4	4 177.6	4 136.8	72 754.2
	No. of M/C or spindles	1L/2S	22	4x2=8	72x12=864	25 056 [c]	96x8=768	20	6	1	96x8=768	32x12=384	1	1	775
	Installed power/M/C (kW)	92	5.15	4.5	3	18.6	13	1	1.5	15	13	1.5	13.5	16.5	3
	Total power (kW)	92	113	36	36	972	104	20	9	15	104	48	13.5	16.5	2 325

Notes: [a] S: Shift [b] M/C: Machine; 480 spindles/frame and 52 frames; [c] 432 spindles/ frame and 58 frames.

Source: Author's review of literature of different sources of textile machinery and survey of 17 textile mills under BTMC.

NB : [a] [b] and [c] mean superscript without strokes, underlines or dashes

Table 15. Comparative staffing level of U.K., Japaneses, Indian and Romanian technologies (spinning).

Technology sources	Production employment[a]					Maintenance employment[a]					Workshop employment[a]					Adm. & others	Total
	S	SS	US1	US2	Total	S	SS	US1	US2	Total	S	SS	US1	US2	Total		
U.K.	20	542	19	84	665	12	13	18	29	72	10	10	9	1	30	205	972
Japan	20	554	19	84	677	13	14	18	29	74	10	10	9	1	30	205	986
India	20	560	19	88	686	15	17	20	35	87	10	10	9	1	30	205	1008
Romania	20	594	19	91	724	15	17	20	35	87	10	10	9	1	30	205	1046

Note: [a] S : Skilled
SS : Semiskilled
US1 : Unskilled (type 1)
US2 : Unskilled (type 2)

Source: Based on author's survey of 18 textile mills in Bangladesh using U.K., Japanese, Indian and Romanian machinery.

Table 16. Comparative staffing levels of U.K., Japanese, Indian and Romanian technologies (weaving and composite).

	Employment[a]																
	Production employment[a]					Maintenance employment[a]					Workshop employment[a]						
Technology source	**S**	**SS**	**US1**	**US2**	**Total**	**S**	**SS**	**US1**	**US2**	**Total**	**S**	**SS**	**US1**	**US2**	**Total**	**Admin. & others**	**Total**
Weaving section																	
U.K.	57	451	141	152	801	19	14	12	16	61	4	1	4	1	10	33	905
Japan	63	505	132	170	870	22	16	13	17	68	4	1	4	1	10	33	981
India	60	493	153	158	864	21	16	13	16	66	4	1	4	1	10	33	973
Romania	60	496	153	158	867	21	16	13	17	67	4	1	4	1	10	33	977
Composite unit																	
U.K.	72	779	144	304	1199	29	25	27	41	122	14	11	13	2	40	238	1599
Japan	78	839	135	222	1274	33	28	28	43	132	14	11	13	2	40	238	1684
India	75	833	156	214	1278	33	31	29	48	141	14	11	13	2	40	238	1697
Romania	75	867	156	217	1315	33	31	29	49	142	14	11	13	2	40	238	1735

Note: [a] S = skilled
SS = semiskilled
US1 = unskilled (type 1)
US2 = unskilled (type 2)

Source: Based on author's survey of 17 textile mills under BTMC using U.K., Japanese, Indian and Romanian machinery.

Table 17. Prouction plan for intermediate spinning technology, 20 units.

	Openning & cleaning (kg)	Carding (kg)	Drawing (kg)	Roving (kg)	Spinning: RFC power	Spinning: ATDA pedal	Cone winding	Reeling	Bundle press
Production									
Rated capacity (kg/machine/shift)	3175.2	70.58	102.06	3.9	97.80 (g)	86.75 (g)	4.54	226.8	725.76
Observed efficiency (%)	70	70	70	70	80	84	70	80	75
Actual or observed prodn/shift	1058.7	50.8	71.22	2.73	78.24(g)[a]	73.14(g)[b]	4.46	181.44	544.32
Required daily prodn (300 days)	508.03	485.35	469.48	460.45	451.33	451.33	446.8	444.53	442.26
Machine requirement (Based on 3 shifts)									
No. of machines or spindles	1/5	4	3x3=9	1x70=70	48x42= 2 016	54x12= 6 504	28x2=56	1	1
Total prodn. capacity (kg)	635.04	609.63	718.5	527.54	501.23	501.23	533.43	544.32	544.32
Power									
Installed power (kW/machine)	15.0	2.25	0.75	3.0	1.5	-	1.5	1.0	1.5
Total installed power (kW)	15.0	9.0	6.75	3.0	63.0	-	3.0	1.0	1.5

Notes: [a] Based on survey of 12 ATDA pedal spinning units in Kusmi Kalan (UP).
[b] Based on survey of an RFC power spinning unit in Coimbatore.

Source: Based on author's survey of RFC power and ATDA pedal spining in India.

Table 18. Comparative manning level of ATDA (pedal) and RFC (power) spinning technologies.

	RFC (power) spinning employment[a]							RFC spinning for composite unit employment[a]							ATDA roving and pedal spinning employment[a]						
Employment	**S**	**SS**	**US1**	**US2**	**Total**	**Unit**	**Total**	**S**	**SS**	**US1**	**US2**	**Total**	**Unit**	**Total**	**S**	**SS**	**US1**	**US2**	**Total**	**Unit**	**Total**
Production																					
Blow room	3	-	9	11	23	4	92	3	-	9	11	23	4	92	3	-	9	11	23	4	92
Spinning[b]	6	5	201	22	234	20	4 680	6	-	177	9	192	20	3 840	-	3	42	3	48[c]	20	960
Maintenance																					
Blow room	1	-	1	1	3	4	12	1	-	1	1	3	4	12	1	-	1	1	3	4	12
Spinning[b]	3	1	7	2	13	20	260	2	-	5	2	9	20	180	1	-	2	-	4	20	80
Workshop																					
Central[d]	5	1	2	1	9	5	46	5	1	2	1	9	5	46	5	1	2	1	9	5	46
Spinning	2	-	-	1	3	20	60	1	-	-	1	2	20	40	1	-	-	1	2	20	40
Management	-	-	-	-	14	20	280	-	-	-	-	14	20	280	-	-	-	-	14	20	280
TOTAL	20	7	220	38	299		5 430	18	1	194	25	252		4 490	11	5	56	17	103		1 510
															Pedal spinners						10 840
																					12 350

Notes: a S: Skilled; SS: Semiskilled; US1 & US2: Unskilled types 1 and 2.
b Manpower requirement given for RFC spinning unit includes subprocess from blowroom to bundle press for spinning and from blowroom to spinning for composite unit; while for ATDA unit from blowroom to roving.
c Pedal spinning at cottage level: 1 spinner per 12 spindles pedal charka.
d An additional material handler is taken for each central workshop.

Sources: Author's survey of Khadi Centre (Ahmedabad and Calcutta, India), Rural Fabric Centre (Coimbatore, India) and Charka and Cottage Industries Organization (Comilla, Bangladesh).

Table 19. Production plan for intermediate technology weaving, 20 units.

	Cone winding (kg)	Pirn winding (kg)	Sectional warping (kg)	Sizing		Pedal looms (m^2)	Power looms (m^2)
				Quantity (kg)	No. of beams		
Production							
Rated prodn. (kg/machine/shift)	4.54	3.86	199.58	244.94	9.6	12.86	29.26
Observed efficiency (%)	70	70	70	65	65	80	75
Actual or observed prodn.	3.18	2.7	139.71	159.21	6.24	10.29[a]	21.95[b]
Required daily prodn. (300 d)	447	219	224	221	9	5093	5093
Machine requirement (based on 3 shift)							
No. of machines	28x2=56	8x4=32	1	1	-	550	90
Total prodn. capacity (kg)	534	259	419	478	19	5 610	5 925
Power							
Installed power (kW/machine)	1.5	1.0	1.5	2.0		-	1
Total installed power (kW) (3 shift)	3.0	4.0	1.5	2.0	-	-	90

Notes: [a] Based on survey of 10 pedal weavers in RFC unit (Coimbatore) and ATDA pedal weavers (Kusmi Kalan, UP)).
[b] Based on survey of 5 private-sector weaving mill in Bangladesh.

Sources: Author's survey of ATDA project in Kusmi Kalan, U.P. and Rural Fabric Centre, Coimbatore, India.

Table 20. Manning level of RFC weaving and composite unit.

Types of employment	Pedal loom							Power loom						
	Employment[a]							Employment[a]						
	S	SS	US1	US2	Total	Unit	Total	S	SS	US1	US2	Total	Unit	Total
Weaving section														
Production	5	9	42	589	645	20	12 900	6	6	169	53	234	20	4 680
Maintenance	4	3	1	6	14	20	280	3	3	4	5	15	20	300
Workshop	2	-	-	1	3	20	60	3	-	1	1	5	20	100
Management	-	-	-	-	11	20	220	-	-	-	-	9	20	180
TOTAL	11	12	43	596	573	20	13 460	12	9	174	59	263	20	5 260
Composite unit														
Production	14	9	228	609	860	4/20[b]	16 832	15	6	355	73	449	4/20	8 612
Maintenance	7	3	7	9	26	4/20	472	6	3	10	8	27	4/20	492
Workshop	8	1	2	3	14	4/20	146	9	1	3	3	16	4/20	186
Management	-	-	-	-	25	4/20	500	-	-	-	-	23	4/20	460
TOTAL	29	13	237	621	925	(897.5)[c]	17 950	30	10	368	84	492	(487.5)[b]	9 750

Notes: a S: Skilled; SS: Semiskilled; US1 and US 2 : Unskilled type 1 and 2.
b 4 Opening and cleaning (blowroom) units and 20 composite units.
c Average employment per composite unit.

Source: Based on author's survey of five private weaving mills in Bangladesh and RFC composite unit in Coimbatore, India.

Table 21. Production plan for intermediate technology service centre, three units.

	Hank to cone winding (kg)	Sectional warping (kg)	Sizing Quantity (kg)	Sizing No. of beams	Handloom beam-winding machine
Production					
Rated prodn. (kg/machine/shift)	4.54	199.58	244.94	4.5	30
Observed efficiency (%)	70	70	65	65	60
Actual or observed prodn.(kg/shift)	3.18	139.71	159.21	3	1.8
Required daily prodn. (300 days)	1415	1400	1386	27	136
Machine requirement (based on 3 shifts)					
No. of machines	28x7=196	4	4	-	3
Total prodn. capacity (kg.)	1870	1677	2047	35	175
Power					
Installed power (kW/machine)	0.375	1.5	2.0	-	0.75
Total installed power (kW) (3 shift)	2.625	3.0	8.0	-	2.25

Sources: Author's survey of ATDA project in Kusmi Kalan, U.P., and Rural Fabric Centre Coimbatore, India.

Table 22. Manning level of service centre.

Types of employment	Employment[a]						
	S	SS	US1	US2	Total	Unit	Total
Production	3	36	58	84	181	3	543
Maintenance	4	2	3	6	15	3	15
Workshop	4	3	1	1	9	3	27
Management	-	-	-	-	15	3	45
Total	11	41	62	91	220	3	660

Note: [a] S: Skilled; SS: Semiskilled US1 and US2: Unskilled (type 1 and 2)

Sources: RFC composite unit (Coimbatore) and ATDA service centre (Kusmi Kalan), India.

Table 23. Khadi and Village Industries Commission (KVIC) technology, balancing of production plan (ambar spinning), 240 units.

	Beater (opener)	Poorva pesai (cleaner)	Carding	Drawing: Uttar peasai	Roving: Ambar charka	Spinning: Ambar charka	Reeling (by charka)	Bundle press
Production								
Rated prodn. (kg or g/machine/shift)	59.88	19.96	19.96	19.96	1.15	70.71	8.16	181.44
Observed efficiency (%)	75	75	75	75	90	87	85	60
Actual or observed prodn. (kg/shift)	44.91	14.97	14.97	14.97	1.04[a]	61.52[b]	6.96	108.9
Required daily prodn. (300 days) (kg)	44.0	44.0	44.0	44.0	40.0	39	38	38
Machine requirement (based on 3 shifts)								
No. of machines or spindles	1	3	3	3x3=9	4x10=40	6x110=660	6	1
Total prodn. capacity (kg.)	44.91	44.91	44.91	44.91	41.20	40.37	41.73	108.86
Power								
Installed power (kW/machine)	0.5	0.5	0.5	0.5	-	-	-	-
Total installed power (kW) (3 shift)	0.5	1.5	1.5	1.5	-	-	-	-

Note: [a] Based on survey of 13 voving spinners.
[b] Based on survey of 67 yarn spinners.

Source: Author's survey of KVIC projects (Ahmedabad and Calcutta, India) Rural Fabric Centre (Coimbatore, India) and Charka and Cottage Industries Organization (Comilla, Bangladesh).

Table 24. Manning level of KVIC hand spinning.

Types of employment	Employment[a]						Total employment
	S	US2	US3	AS	Total	Unit	
Production	1	1	15	126	143	240	34 320
Supervisor (prodn. and maint.)	1	-	-	-	1	240	240
Management	-	-	-	-	2	240	480
Total	2	1	15	126	146	240	35 040

Note: [a] Skilled; US2 and US3: Unskilled (type 2 and 3); AS: Ambar hand spinner.

Table 25. Traditional technology production plan (pit and CR loom).

	Bobbin winding (kg)	Natai and tana (pre-warping (kg)	Drum making (warping) (kg)	Nali making (pirn (winding) (kg)	Pit loom (m^2)	Chitta Ranjan (CR) loom (m^2)
Production						
Rated prodn.(kg/machine/shift)	1.9	4.54	9.07	1.81	14.53(m)[a]	19.28(m)[a]
Observed efficiency (%)	83	82	82	86	70	78
Actual or observed prodn./shift	1.59	3.74	7.48	1.56	10.17[a]	15.04[a]
Required daily prodn. (300 days)	4516	4427	4383	4329	50526	5076
Machine requirement (based on 3 shifts)						
No. of machines	2860	-	590	2790	13 824	10636
Total prodn. capacity (kg)	4540.54	-	4415.8	4354.56	110102.9(m^2)	110093.8(m^2)

Notes: [a] maximum daily production.
[b] average daily production.

Source: Author's survey of 214 cottage weaving units in different areas of Bangladesh.

Table 26. Employment in the traditional handloom sector.

Subprocess loom type/ employment	Bobbin	Natai & (sizing & warping)	Drum (beaming)	Nail (pirn winding)	Sana & Ba (drawing-in)	Weaving	Total employment
Pit loom	2 860	1 180	586	2 790	604	13 824	21 844
CR loom	2 860	1 180	586	2 790	345	10 636	18 397

Table 27. Total employment of alternative technologies.

Alternative spinning technologies		Alternative composite technologies	
Alternatives	**Total employment**	**Alternatives**	**Total employment**
Modern spinning		**Modern composite**	
U.K.	972	U.K.	1 599
Japan	986	Japan	1 684
India	1 008	India	1 697
Romania	1 046	Romania	1 735
ATDA, RFC & KVIC spinning		**RFC composite**	
ATDA pedal spinning	12 350	RFC spinning and pedal loom	17 950
RFC power spinning	5 430	RFC spinning and power loom	9 750
KVIC hand spinning	35 040		
Service centre	660	**Combined (modern, intermediate and traditional) alternatives**	
		LC spinning and pit loom[b]	22 852
Handloom alternatives		LC spinning and CR loom	19 405
Pit loom	21 844	LC spinning, SC and pit loom[c]	18 886
CR loom	18 397	RFC power spinning and pit loom	27 274
		ATDA pedal spinning and pit loom	34 194
Service centre and pit loom[a]	17 218	KVIC hadn spinning and pit loom	56 884
Service centre and CR loom[a]	13 771		

Notes: [a] Excludes traditional preparatory weaving employment.
[b] LC=least cost.
[c] SC=service centre.

Table 28. Total investment costs of alternative technollogies (BDT 000 000) to produce 31 million m^2 cloth yearly at 5% discount rate.

Alternative spinning technologies		Alternative composite technlogies	
Modern spinning		**Modern composite**	
U.K.	182.64	U.K.	342.10
Japan	167.22	Japan	282.26
India	142.16	India	263.68
Romania	145.90	Romania	270.63
ATDA, RFC & KVIC spinning		**RFC composite**	
ATDA pedal spinning	135.21	RFC spg. and pedal loom	336.49
RFC power spinning	130.18	RFC spg. and power loom	233.35
KVIC hand spinning	277.20		
		Combined (modern, intermediate and traditional) alternatives	
Service centre	20.42		
		LC spg. and pit loom	197.90
		LC spg. and CR loom	223.34
Handloom alternatives			
		LC spg. SC and pit loom	215.59
Pit loom	55.74		
		RFC power spg. and pit loom	185.92
CR loom	81.18		
		ATDA pedal spinning and pit loom	190.95
Service centre and pit loom	73.43		
Service centre and CR loom	99.80	KVIC hand spinning and pit loom	332.94

Table 29. Total annual operating costs of alternative technologies (BDT 000 000).

Alternative spinning technologies

Technology	At acutal productivity		At expected productivity	
	SC	Handloom	SC	Handloom
Modern spinning[a]				
U.K.	113.94	114.74	112.00	112.80
Japan	111.69	112.48	110.30	111.09
India	112.88	113.73	110.47	111.26
Romania	112.68	113.53	110.64	111.65
ATDA, RFC and KVIC spinning				
ATDA pedal spinning	-	163.93	-	163.93
RFC power spinning	-	144.08	-	138.91
KVIC hand spinning	-	222.53	-	222.53
Service centre	-	154.67	-	154.67
Handloom alternatives				
Pit loom[b]	232.08	224.76	232.08	224.76
CR loom	231.24	223.89	231.24	223.89
Service centre and pit loom	-	212.62	-	212.62
Service centre and CR loom	-	211.76	-	211.76

Alternative composite technologies

Technology	At actual productivity	At expected productivity
Modern Composite		
U.K.	143.27	139.6
Japan	142.01	138.6
India	140.98	136.8
Romania	142.14	138.3
RFC composite		
RFC spg. and pedal loom	214.62	206.1
RFC spg. and power loom	186.25	182.1
Combined (modern, intermediate & traditional) alternative		
LC spg. and pit loom	206.34	203.8
LC spg. and CR loom	205.47	203.0
LC spg., SC and pit loom	187.08	184.6
RFC power spg. and pit loom	229.59	224.4
ATDA pedal spg.& pit loom	249.43	249.4
KVIC hand spg. and pit loom	308.03	308.0

Notes: [a] Modern spinning supplying yarn to service centre (SC) and handloom sector.
[b] Yarn supplied from modern spg./intermediate spg.

Table 30. Capital/labour (K/L) cost, present value cost (PVC), net present value (NPV) and present value cost/unit (PVC/unit) of alternative spinning technologies at estimated actual and manufacturers' recommended or expected level of productivities, at 15% discount rate (BDT 000 000).

Alternative technology	Ranking	Total capital cost(K)	Employment(L) (000)	K/L (BDT 000)	Annual operating cost at productivities		PVC		NPV		PVC/unit (BDT)		PVC in excess of LC	Increase in (L) over LC spinning	Cost/additional job compared to LC (BDT 000)
					Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected			
Modern spinning															
India (LC)	I	161.40	1 008	160.12	113.73	111.26	607.22	597.16	(26.09)	(16.03)	5.40	5.31	-	-	-
Romania (SB)	II	165.64	1 046	158.36	113.53	111.65	610.06	602.14	(28.90)	(20.90)	5.43	5.36	2.84	38	74.74
Japan	III	189.99	986	192.69	112.48	111.09	626.27	620.63	(45.02)	(39.38)	5.57	5.52	19.05	(22)	-
U.K.	IV	207.58	972	213.56	114.74	112.80	650.97	642.53	(69.21)	(61.21)	5.79	5.72	43.75	(36)	-
Intermediate spinning															
RFC power	V	130.58	5 430	23.97	144.08	138.91	723.48	701.85	(143.08)	(121.45)	6.44	6.25	116.26	4280	27.16
ATDA pedal	VI	135.28	12 350	10.95	163.93	163.93	803.80	803.80	(223.30)	(223.30)	7.16	7.16	196.58	11260	17.46
KVIC hand	VII	277.20	35 040	7.91	222.53	222.53	1187.20	1187.20	(604.08)	(604.08)	10.57	10.57	579.98	34032	17.04

Notes: LC: Least-cost spinning technology.
SB: Second-best spinning technology.
Figures in bracket are negatives.

Table 31. K/L, PVC, NPV and PVC/unit of alternative handloom technologies at productivity using 15% discount rate (BDT 000 000).

Technology	Ranking	Total capital cost(K)	Employ-ment(L)	K/L (000)	Annaual operating cost	PVC	NPV	PVC/unit (BDT)
Warp beam from service centre								
Pit loom	I	73.45	17 218	4.26	212.62	944.94	46.57	1.275
CR loom	II	99.80	13 771	7.25	211.76	967.69	23.92	1.306
Yarn from RFC spinning								
Pit loom	III	55.74	21 844	2.55	224.76	976.51	14.17	1.317
CR loom	IV	81.18	18 397	4.41	223.89	998.46	(7.69)	1.347
Yarn from modern spinning								
Pit loom	V	55.74	21 844	2.55	232.08	1006.55	(15.87)	1.358
CR loom	VI	81.18	18 397	4.41	231.24	1028.50	(37.73)	1.388

Table 32. K/L, PVC, NPV and PVC/unit of alternative composite technologies at estimated actual and manufacturer's recommended or expected level productivities, at 15% discount rate (BDT 000 000).

Technology	Ranking	Total capital cost(K)	Employment(L) (000)	K/L (BDT 000)	Annual operating costs at productivities		PVC		NPV		PVC/unit (BDT)		PVC in excess of LC	Increase in (L) over LC Spinning	Cost of additional job compared to LC (BDT 000)
					Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected			
Modern composite															
Indian (LC)	I	263.68	1697	155.54	140.98	136.84	838.94	822.78	161.21	177.36	1.132	1.110	-	-	-
Romanian (SB)	II	270.63	1735	155.98	142.14	138.38	850.60	835.95	149.69	164.35	1.148	1.128	11.66	38	306.84
Japanese	III	282.26	1685	167.61	142.01	138.65	861.35	848.28	138.90	151.96	1.162	1.145	22.41	(13)	-
U.K.	IV	342.10	1599	213.95	143.27	139.67	923.75	909.89	76.74	90.60	1.246	1.288	84.81	(98)	-
Modern/intermediate/traditional composite															
LC+SC+pit loom	V	215.59	18886	11.42	187.08	184.67	980.90	971.13	19.44	29.21	1.333	1.310	141.96	17189	8.26
RFC power loom	VI	233.35	9750	23.92	186.25	182.14	1001.88	985.35	(2.89)	13.63	1.351	1.329	162.94	8053	20.23
LC+pit loom	VII	197.90	22852	8.66	206.34	203.87	1041.52	1031.46	(41.96)	(31.90)	1.405	1.392	202.58	21155	9.58
LC+CR loom	VIII	223.34	19405	11.51	205.47	203.00	1063.47	1053.41	(63.82)	(53.76)	1.435	1.421	224.53	17708	12.68
RFC spg+pit loom	IX	185.92	27274	6.82	229.59	224.42	1128.62	1106.98	(129.78)	(108.61)	1.523	1.494	289.68	25557	11.33
ATDA spg+pit loom	X	190.95	34194	5.58	249.43	206.13	1208.94	1182.39	(210.00)	(182.26)	1.631	1.595	370.00	32497	11.38
RFC pedal loom	XI	336.49	17950	18.75	214.62	249.42	1221.62	1208.94	(221.49)	(210.00)	1.648	1.631	382.68	16253	23.55
KVIC spg+pit loom	XII	332.94	56884	5.85	308.03	308.03	1592.33	1592.33	(590.79)	(590.79)	2.148	2.148	753.39	55187	13.65

Notes: LC: Least cost composite technology.
SB: Second best composite technology.
LCS+SC: Least cost spinning (Indian) and service centre.

Table 33. PVC, NPV and PVC/unit of selected composite technologies at efficiency factor prices and actual productivity at 15% discount rate (BDT 000 000).

Technology	Ranking	Total capital cost	Annual operating cost	PVC	NPV	PVC/unit (BDT)
Modern composite						
Indian (LC)	I	294.51	136.94	853.13	147.01	1.151
Romanian (SB)	II	302.59	138.00	865.47	134.82	1.168
Modern/intermediate/traditional composite						
RFC power loom	III	244.75	170.77	949.54	49.44	1.281
LCS+SC+pit loom	IV	229.97	184.42	984.51	15.84	1.328
LCS and pit loom	V	212.28	203.36	1043.62	(44.07)	1.408

Notes: LC: Least-cost composite technology
SB: Second-best composite technology
LCS+SC: Least-cost spinning (Indian) and service centre.

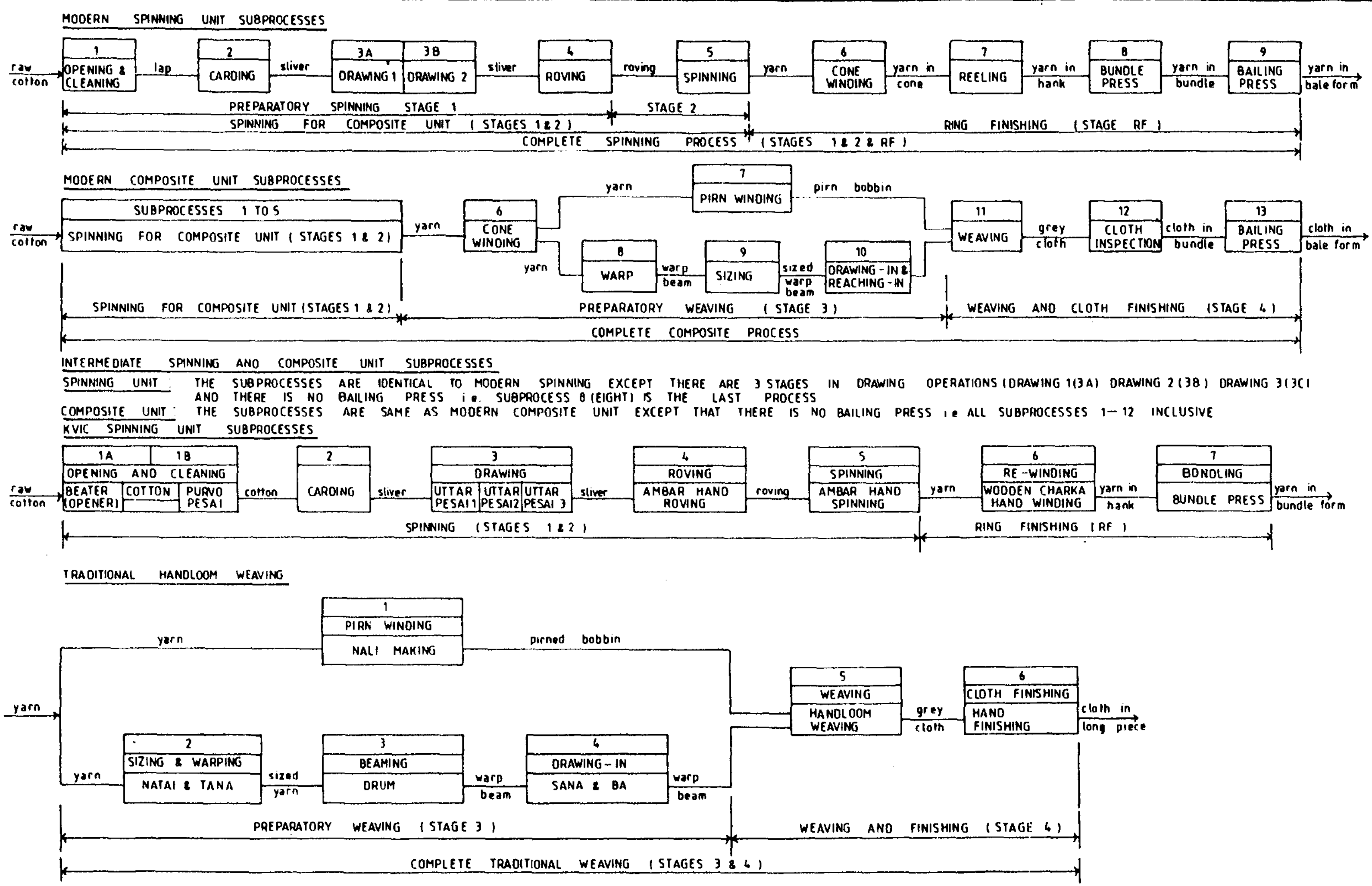

Fig.1. Subprocesses of modern, intermediate and traditional technologies.

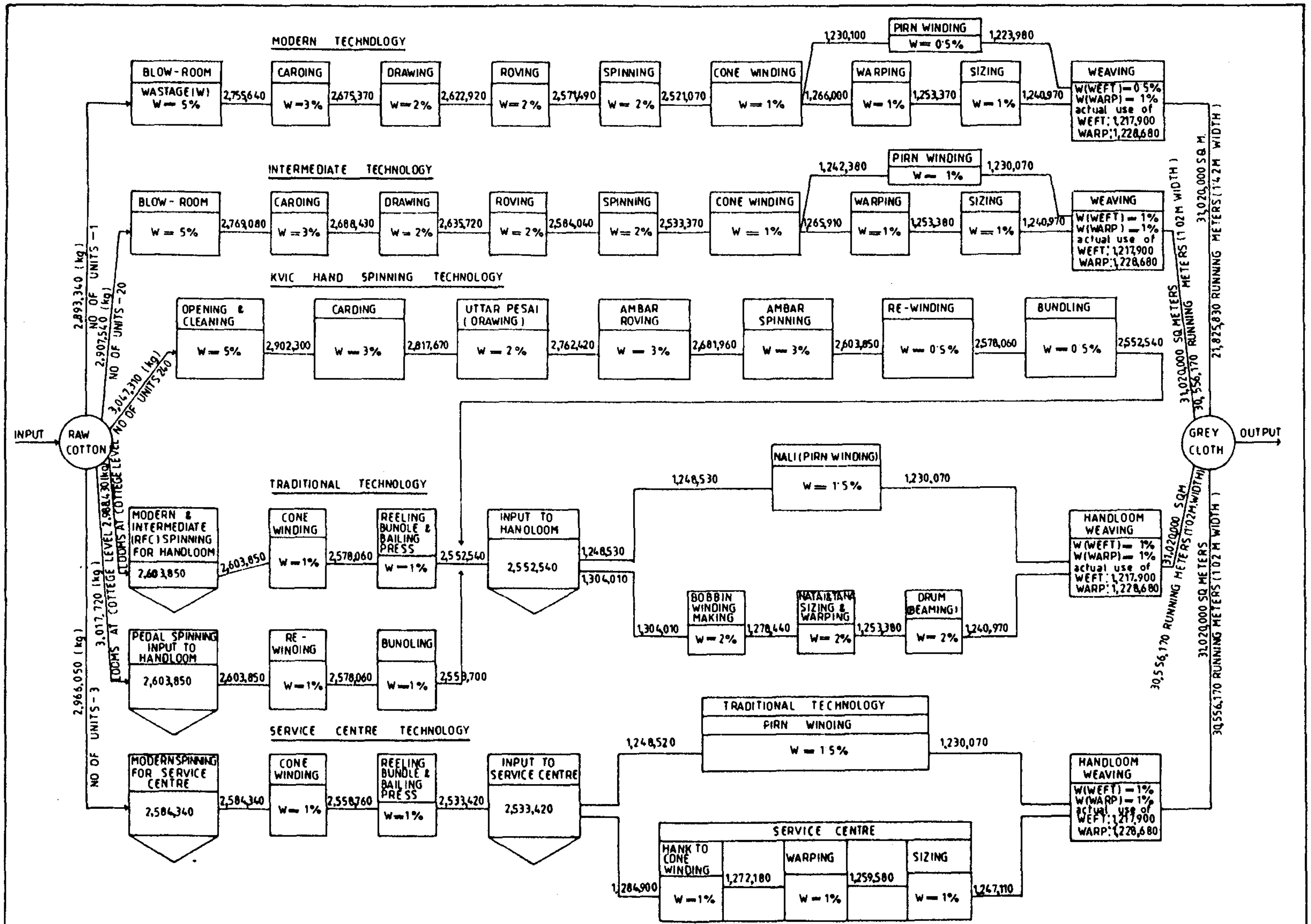

Fig. 2. Input-output balancing for alternative technologies.

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